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WE INVITE PRACTICAL ARTICLES ON THE TRADE IN ALL ITS BRANCHES, WHICH WILL BE PAID FOR MSS. SHOULD BE WRITTEN ON ONE SIDE OF THE PAPER ONLY.

BRITISH FOUNDRYMEN'S ASSOCIATION.

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Forthcoming Events.

SEPTEMBER 27 TO OCTOBER 1.

Iron and Steel Institute.—Autumn meeting.

OCTOBER 14 AND 15.

Institute of Metals.—Annual meeting at Manchester.

NOTES AND COMMENTS.

The Convention Idea.

For the sixth time the representatives of the British foundry workers from all over the country have foregathered to compare ideas, offer each other suggestions, learn from each other, criticise each other, and generally unite to give another turn to the wheel of foundry progress. Nor does the enthusiasm of the members of the British Foundrymen's Association abate as time goes on. It rather increases, for we find them readily agreeing to increased subscriptions and eager for an extension of their sphere of activity. We are not sufficiently concerned with the history of sociology to inquire at what early date mankind found that by foregathering and discussing matters of mutual interest, mutual advantage resulted. We are concerned only with the fact that the practice is becoming increasingly popular, and that too, in trade circles once so secretive that only a few years ago the idea was regarded as distinctly dangerous. Perhaps in no direction more than the foundry trade has the spirit of conservatism been so pronounced in the past; but that is perforce giving way before the advance of modern ideas. The man who tells his fellows of the difficulties he experiences in his work and also of the successes he has attained by various methods, is no longer regarded as a fool; he is simply a wide-awake fellow on the look-out for knowledge, and willing to barter his own for it. He realises also, that he does not lose anything in helping his fellows, but rather assists them to help him in return. So we find the leading lights of the foundry trade fraternising and benefiting thereby; for they have got the convention idea and find it a workable asset. Is it any wonder, then, that the Birmingham Convention has been pronounced another success?

Increased Fees and Progress.

A significant feature of the Birmingham meetings was the resolution adopted regarding the membership subscriptions. The Association realises that it is not advisable to hamper its movements and restrict its progress on account of pecuniary considerations. While the old scale of membership fees was doubtless very well suited to the needs of the newly-formed Association, and served to cover expenses for the time, it was not sufficiently productive to allow the expansion of work which ultimately became desirable. As it is, the new scale of fees falls far below that of the American Foundrymen's Association, which is an organisation of exactly the same nature; nor can it be regarded as other than very cheap, when the advantages of membership are considered. The publication in handy book form of the full proceedings of such an Association is, of course, recognised as an essential, and will add considerably to the prestige of the organisation, apart from the general utility of such a volume to the foundryman. If the requirements of the British Foundrymen's Association demand in the future a still higher subscrip-

tion from the members, in order to carry out the educational schemes before them, we do not think much objection will be raised. It will, in any case, be money well invested.

But while the subject of progress and development is before us, may not the question—"Why not a London Branch?"—be again raised. We are still of the opinion that there is plenty of material in and around London to form a Branch of the Association. London may not be a great foundry centre, but there are enough iron and brass foundries within easy reach of the city to supply members in abundance. We believe the hope that such a Branch would be founded was expressed by Mr. Robert Buchanan some time ago, when delivering his now famous lecture on "The Application of Science to Foundry Work," before the Society of Arts. The idea has not yet materialised, but we still hope.

The Question of Training.

Mr. Cook, in the course of his Presidential address touched upon the question of technical training for the boy who leaves school at the age of 14, or earlier, and is not always directed into the most suitable ranks of industrial life. It is an unfortunate feature of our present-day life that the old system of industrial apprenticeship is gradually disappearing. Not only that, but so far nothing has been substituted for it. Whatever faults the apprenticeship system may have, there is a lot to be said in favour of placing a boy under the control of a master of the craft chosen for the boy's future work. He thus passes through a more or less definite training and at the completion of that he is both in age and experience practically a fully qualified worker. In the absence of such a definite training he is far less likely in the same time to be able to take an efficient part in life, though with a superficial knowledge of his trade he will, perhaps, take a place in the ranks. But that is not all that is necessary; the education which a man obtains through intelligent application to his work is too often wanting, and then the man can only be classed as an operative, and not as an efficient worker. Further, the early training which allows a boy to become an incompetent workman will keep him in that position, in the absence of a very definite incentive to improve himself. Whether the preparation for entering the industrial ranks which Mr. Cook advocates—presumably technical or mechanical instruction—would prove of much service as compared with the same period of a direct apprenticeship, it is impossible to say, for apart from the fact that at the age of thirteen it is difficult to gauge a boy's capacity and inclinations, such preparatory instruction could only be comparatively meagre. But against that objection must be set the fact which Mr. Cook claims, that "the pupil would be stimulated to effort by the sense of power which comes from knowledge." After all, given an increased stimulus to mental development—and that is really what all mechanical or technical instruction amounts to—the natural bent of the individual will assert itself to better effect.

We labour this point of the education of the rising generation, and we will continue to labour it, for it must be impressed upon our educationalists unless their efforts are to be shadowed with ill-success. We are glad it occupies such a prominent position in the propaganda of the British Foundrymen's Association.

"Rule-of-Thumb" and Science.

After a perusal of Mr. Sidney G. Smith's paper, in which he deals with the application of "Rule-of-Thumb" methods in the foundry, we find ourselves wondering whether the author really intended to present such a strong plea for the adoption of scientific methods as he actually does present. He starts by enthusiastically advocating the cause of the rule-of-thumb workers, and asks who would be left if these men were taken from the foundry. Well, if we answer that question as it is put, the reply would be "very few, indeed"—that is, if we accept Mr. Smith's full meaning of the term "rule-of-thumb." But first let us clear the ground by defining the term. On turning to "Webster," we find that it implies any rude process or operation, like that of using the thumb as a rule in measuring; hence, judgment and practical experience, as distinguished from scientific knowledge. Science, we take it, is as we are now considering it, the knowledge of principles and causes—ascertained truths or facts. We are afraid that Mr. Smith did not keep these definitions sufficiently clearly before him when he started by objecting to the statement (which appeared in an article in this paper, by a foundry contributor) that "rule-of-thumb workers are daily confronted by an absolute failure of their pet rules, etc." The fact is, he starts by assuming that the two classes of workers are practically distinct, apparently conceiving the scientific worker to be merely a book-student of foundry matters. Let us in turn ask the author of what value the remaining workers would be if all those with any scientific knowledge of their work were taken away? A competent worker must necessarily combine a considerable knowledge of the scientific side of his work with the experience of actual practice. It is as well to realise that any operation which is not based on science—*i.e.*, the knowledge of principles and causes—is empirical. That is to say, the result cannot be predicted with certainty, as conditions may not be exactly the same as in the former cases upon which conclusions have been founded. Will the author of the paper deny that there are very many moulders, for instance, who base the whole of their procedure on past experience of similar work, ignoring often slightly changed conditions and properties in the materials being handled? We think he will admit it. On the other hand, there is the man who has, by experience and observation acquired what is practically a store of scientific knowledge. He may not call it such; he often openly boasts of his superior rule-of-thumb knowledge. But give him a new piece of work to handle, and he will bring to bear upon the case all his accumulated knowledge—much of it scientifically accurate—and after considering all the conditions involved, will operate successfully. There are times, however, when a new feature will quite upset the whole conclusions, and failure will result. Mr. Smith admits that there is a continual change occurring in the conditions which exist in foundry work. This being the case, how can any man who works only on past experience, without a knowledge of the principles and causes of the phenomena he encounters, successfully meet new conditions. If past experience alone is to be the qualification of a good worker, what are we to do when new conditions arise? We must, obviously, call to our aid the man who understands those new conditions and their effect. As he proceeds with his subject Mr. Smith tactically admits that the best worker is the one who combines practical experience with scientific knowledge and understands both how to deal with definite phenomena and the causes of their occurrence. We hope he does not think that when we advocate scientific working we desire to substitute for the training and experience in moulding that is attained on the moulding floor a code of rules and regulations regarding certain phenomena. Far from it. We want the rule-of-thumb man to know more clearly on what his rules are based, so that he may adapt himself to changing conditions without need-

less experiment and waste. He is essentially a man of capability, or he would not be even a rule-of-thumb man, but if he is only that, then he falls short of the mark. Incidentally, there is a subtle suggestion that Mr. Smith is trying to oppose the claim that the foundryman is not sufficiently scientific, and at the same time making a reservation in favour of the work of various members of the British Foundrymen's Association, which work has undoubtedly been on scientific lines. He could better console the two ideas were he first to define the qualities of the men he is supporting, for he would find that rule-of-thumb methods are, metaphorically speaking, the ore from which we obtain the metal of scientific procedure. We note, also, that in the course of his paper the author claims that the design of castings should be influenced by certain laws of contraction during the solidification—in short, that a knowledge of scientific facts should govern actual practice.

Bad Design and Foundry Troubles.

It would be useless to deny that Mr. W. H. Sherburn touches a sore point, in his paper on "The Production of Patterns for Light Castings," when he remarks on the trouble often caused through the designer not understanding the properties and tendencies of cast iron. It is an unfortunate feature of foundry work that no formula can be set before the designer to guide him in avoiding structural defects and weaknesses. He can know to within a little the amount of stress and strain various forms, sizes and qualities of wrought or rolled iron and steel will withstand; he can calculate with mathematical precision the capacity and strength of any part of a complicated iron or steel structure, basing his calculations on simply the known strength of the material used. But when he comes to cast iron he may easily fail on what appears to be the simplest of castings, and will demand of the foundryman an article which it may be practically impossible to produce soundly. The essential difference between the two classes of work is that wrought or rolled iron and steel is practically constant in its properties of strength, resistance, etc., from the time it leaves the manufacturer's hands to the time it takes a permanent place in a structure, while cast iron is a decidedly varying quantity, and may be variously affected by a number of conditions up to the last moment it takes its final form. Cast iron is not subject to any workable formula on which its ultimate strength may be accurately pre-determined. There is scarcely a single design of casting, beyond perhaps straight bars, that is not subject to more or less variation in strength in different parts, and it is over that feature that the designer too often stumbles. This is illustrated by the remarks made at a recent meeting of the Engineers' Society of Western Pennsylvania by a user of steel castings. This gentleman had been using in the construction of rivetting machines steel castings consisting of U-shaped parts having a heavy tension section, a lighter compression section and a comparatively thin web. A very thin web was at first decided on, and as a result the castings cracked all around the web close to the flanges. The foundryman then said a big fillet must be used to avoid such cracks. Putting in ribs to stiffen the web was tried, but that made matters worse, cracks then occurring along the ribs. Finally, the ribs were done away with and a heavier web employed, but it took some time for the designers to find that the fewer the stiffening ribs and the heavier the web, the better were the castings. The speaker remarked, "I think it cost the steel casting people a great deal because we did not know how to design steel castings. If they had told us that we were making a mistake in our designs we would have changed the patterns."

Here were users of steel castings that were required to withstand a good deal of strain, demanding a design that obviously run counter to the (in foundry circles) well-known rules of contraction and shrinkage—for what intelligent foundryman would think of combining a very thin web and a thick rim in an article where strength was needed. But the designer simply didn't understand anything about foundry practice; he had certainly not had the period of practical training that Mr. Sherburn advocates, though he certainly would have benefited by it.

An Association of German Foundrymen.

Despite the fact that Germany's foundry trade ranks amongst her important industries, there has not until recently been any Association formed for the advancement of the scientific interests of the work. There has now been formed, however, the Verein Deutscher Giessereifachleute (German Foundrymen's Association), whose headquarters are at Berlin-Charlottenburg, Sybelstrasse, 60. The movement to form this Association has received the co-operation of many prominent representatives of the foundry interests and managers of foundry establishments. The Association aims, by means of an intimate co-operation of its members, at the advancement of foundry affairs in a scientific and technical direction. The formation of a German Association on the same lines as our own, and that of the American foundrymen is welcome, for it will probably enable us to get into much better touch with German methods. That country is sufficiently advanced in scientific and technical directions to ensure us learning something, and at the same time we are doubtless in a position to do the same for them.

White Metal for Patterns.

A good white-metal pattern mixture must melt readily, cast with exceeding sharpness, and not be too expensive. While bismuth is frequently added to white-metal pattern mixtures to lower the melting point, not only is it expensive, but it is apt to lower the melting point to such a degree that soldering is difficult. A manufacturer, writing to "The Brass World," gives a mixture for making white-metal patterns which is very close to the one frequently employed containing bismuth, but is free from it and is not expensive. When properly mixed and poured it is said to give excellent results. The composition is as follows:—Tin, 7 lbs.; lead, 7 lbs.; antimony, 2 lbs. For general work this probably cannot be improved upon.

MR. W. VALIANT, of Whitley & Valiant, Limited, hinge manufacturers, Ashton, Lancashire, died recently aged 75 years.

MR. C. M. SCHWAB, President of the Bethlehem Steel Company, has been inspecting the Dominion Iron and Steel Company's plant at Sydney, Nova Scotia, paying particular attention to the duplex process of steel conversion as practised there.

MR. D. N. THOMSON, senior partner of the West End Engine Works Company, engineers, 170, Dundee Street, Edinburgh, died on August 18, in his 67th year. The deceased was a nephew of the late George Bertram, engineer, Sciennes Works, Edinburgh, with whom he served his apprenticeship, eventually becoming one of his right-hand men. He began business on his own account about 1873, and was successful in building up a large general engineering business from very small beginnings.

British Foundrymen's Association.

The Annual Convention.

The British Foundrymen's Association, though its inception is attributed to Birmingham, has not until this year met in that city. The Sixth Annual Convention, held there in Bank Holiday week this year, proved one of the most successful of the series. In Birmingham and district the week is almost generally observed as a factory holiday and consequently, some difficulty was found in arranging the visits to works, which have come to be an important feature of the Convention. Thanks, however, to the perseverance of the local committee, and the courtesy of certain firms and authorities, the Convention this year left nothing to be desired in this respect, while the drive through Shakespeare's country formed a

MR. F. J. COOK, PRESIDENT.

pleasant termination to the labours of the week. The visit to the University buildings recently opened by the King was not the least interesting item of the programme.

To the University, also, the Convention was indebted for the meeting place. The business meetings, and the reading of papers took place in the Medical Theatre of the original University buildings in Edmund Street. The members met there on the mornings of Tuesday, August 3, and Wednesday August 4, the afternoons and evenings being given up to visits of inspection and social engagements. Mr. F. J. Cook (who was elected President at Newcastle last year) presided on each occasion, and among those who took part in the meetings were:—Mr. H. Pilkington and Mr. R. Buchanan, Past-Presidents; Messrs. P. Longmuir and C. Jones, Vice-Presidents; F. W. Finch, Treasurer; J. E. H. Allbut, Secretary. The following members signed the attendance roll:—C. Heggie, H. Winterton, G. Hailstone, J. Bullock, J. B. Tattersall, H. L. Reason, R. Mason, T. Fraser, C. Grindley, P. T. Bailey, C. Mack, L. Pearse, N. Overend, F. E. Robinson, J. Poole, W. Gower (Birmingham), T. Baugh, D. Dalyrymple (West Bromwich), Wm. Jones (Blaenavon, Mon.), S. J. Smith (Chesterfield), V. L. Cammell (Newark), R. Carrick (Shapley, Yorks), P. Munnoch, J. E. Fangrieve, R. Mather (Middlesbrough), Jos. Chadwick, J. Peers (Bolton), M. H. Curnow (Penrhyn Cwll.), G. Buchanan (Wrexham), E. C. Burnop (Newcastle), T. Swinden, V. C. Faulkener, W. Sykes, L. Redmayne (Sheffield), D. Cartwright (Lichfield), E. Richards (Bradford), C. Dobson, J. J. Dobson, H. Grandidge (Bury, Lancs.), W. J. Jackson (Exeter), G. M. Mather, (Ashford, Kent), S. Waterhouse (Letchworth, Herts), W. E. Noon (Halifax), W. H. Sherburn (Warrington), W. Jewson (Dereham), T. C. Pemberton, V. Jobson (Derby), W. B. Parker (Rugby), Thos. McFarlane (Horsehay, Salop), D. Bray (Walsall), T. Pass (Tipton), W. Gill (Garston, Liverpool), Wm. Sword (Dudley), Andrew Hunter (West Hartlepool), S. Dawes (Coalbrookdale), J. J. Robinson (Ripley, Derby), E. Richards (Deepfields), A. Leidig (Manchester), H. Bowman (Burnham-on-Crouch), H. E. T. Brecknell (Bristol), Jno. Ure (Stockton Heath, Warrington), S. A. Simson (Leicester), W. H. Jagr (Birmingham), C. Grindley (Birmingham), J. Shaw (Dudley), H. P. Meson (Oldham).

Apologies were received from Mr. R. A. Kenyon (Accrington), Mr. W. F. Bagnall (Sheffield), W. J. Ellis (Southampton), and C. Morehead (Stafford).

The PRESIDENT, in opening the Convention, said:—Gentlemen, in giving you a hearty welcome to this our Sixth Annual Convention, I will say that I hope you will find it as successful and as helpful as the others have been. The local Committee have been at great pains to do everything possible to ensure success. We have come into a centre where they are not supposed to be at work this week, and our difficulties consequently have been very great. Still we have arranged a programme that I think will be pleasant and profitable to all the members here.

Progress of the Association.

The HON. SECRETARY (Mr. J. E. H. Allbut) having read the minutes of the Convention held last year at Newcastle-on-Tyne, the Council's annual report and financial statement (which appeared in the FOUNDRY TRADE JOURNAL last month) were taken as read.

MR. F. W. FINCH (Hon. Treasurer) said that on looking through their last report he found that the Association was not making the progress that he thought it ought to be making, and suggested that a small committee be appointed either from the Council or from the general body of members to devise the best means of advancing the Association.

The PRESIDENT said that a small committee had been formed, and a circular issued with the view of increasing the membership, though without much result. Another small committee was formed to consider the means of increasing the income from the members. This it was proposed to do by means which would be submitted subsequently to the meeting.

MR. CARRICK thought they were all agreed that they should push matters forward as fast as they

could, and that the vital thing on that occasion was listening to the papers. It occurred to him that the increase of membership was a work not so much for a committee as for individual propaganda. No committee could get into touch with foundrymen and proprietors so well as individuals could. Let every one undertake to be himself a committee and speak to the men he knew, and then communicate with the Secretary. In that way they would do far more to increase the membership than by the formation of any committee.

Mr. Sherburn thought they had not had sufficient time to discuss the working of the Association. The report showed that a committee had been appointed and had been taking the matter in hand. There was a clear recommendation in the report, and the discussions, if any were required, ought to take place on that. The Council knew the views of the various Branches on the question, and they had also the recommendation of the Lancashire Branch to consider.

Mr. Sherburn moved that the report and accounts be adopted.

Mr. Heggie, referring to the item of £1 19s. 1d. for Branch expenses, explained that the Birmingham Branch had not made any complaint with regard to the financial arrangements. It had never received any financial aid since the Association started. He thought it would be just as well to mention the Branches who had received aid.

Mr. Pilkington said that subject of Branches and Branch membership was coming up in another form.

Mr. Jones seconded the adoption of the report and financial statement. Although it was said that the membership was not increasing they knew perfectly well that the work was greatly increasing. He should like to recognise the work of their Secretary. None of them liked to work for nothing, though in a good cause they might be willing to work under price, but they liked even that to be recognised. He thought everyone in the room would wish to recognise the work of their Secretary, and he should have great pleasure in seconding the adoption of the report with the addition that £20 be granted to Mr. Allbut for his services.

Mr. Longmuir said that everybody knew that their Secretary had worked heart and soul for the Association. He had not been talking; he had been working. This honorarium certainly was not in any sense paying him; it was a mere acknowledgment of services rendered. He had much pleasure in supporting this resolution.

The President: I have much pleasure in putting the resolution with the addition that we give £20 as an honorarium to our Secretary.

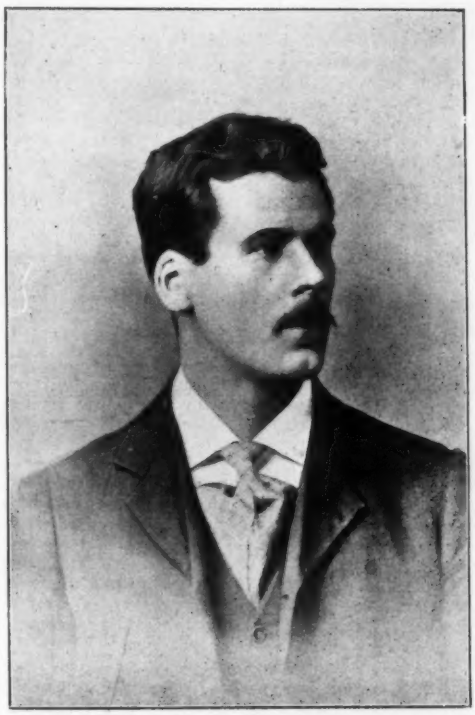
The motion was carried unanimously.

Election of Officers.

The President then declared all offices vacant.

Mr. Longmuir: I beg to propose the re-election of Mr. F. J. Cook as President of the Association for the coming year. (Applause.) You have been told that the Association is not making any progress. That I for one flatly deny. (Hear, hear.) You have been partly told that our officers are not endeavouring to make progress. That also I deny. In this last year, certain changes have been made, and while Mr. Cook has occupied the chair the Association has progressed in point of membership and also more and more in point of influence. (Hear, hear.) An Association is useless unless it can carry some weight, and this Association has been steadily gaining in influence; it is steadily progressing generally. The report before you is one very good example of this; and all that is mainly owing to the activity of our President last year. In asking him to take office for the coming year, we are paying ourselves a compliment. (Hear, hear.) I have very much pleasure then in proposing that Mr. Cook be re-elected President for the coming year. (Applause.)

Mr. Pilkington: I have very great pleasure in seconding Mr. Longmuir's proposition. Those of us who are on the Council know very well the excellent work Mr. Cook has done during the past year. He has kept closely in touch with the Association, and has worked hard himself; he has exerted a very important influence owing to his great practical abilities. It has been a good thing for this Association to have had a really good practical foundry manager as its President for two years.



Mr. P. Longmuir, Senior Vice-President.

The motion was then carried unanimously.

The President, acknowledging his election, said that from the first he had done all he could to further the interests of the Association, and hoped he would go on doing that for many years to come. (Applause.)

Mr. Buchanan, in proposing that Mr. Percy Longmuir be re-elected Senior Vice-President, said that both on the scientific and on the practical side, Mr. Longmuir had made himself eminent, and had been exceedingly useful to their Association.

Mr. Gibson seconded the proposal, which was carried with applause.

Mr. Longmuir briefly acknowledged his re-election.

The President proposed Mr. C. Jones as Junior Vice-President, describing him as a practical foundryman who had worked on the floor. In an Association which tried to look deeply into the practical side of matters, they were very fortunate in having a man like Mr. Jones as Vice-President. (Applause.)

Mr. Finch seconded the proposition, which was carried unanimously, and Mr. Jones acknowledged his election.

Mr. Gibson proposed the re-election of Mr. Finch as Treasurer, Mr. Sherburn seconding.

The President, in putting the proposition, said that Mr. Finch had done very good service for the Association, and they had no doubt he would continue to do so. (Hear, hear.)

The re-election was unanimously agreed to.

The President: The next election is that of Secretary. No one in any society knows or feels more the value of the Secretary's help than does the President, and I can safely say that no President has had better support than I have had from Mr. Allbut. (Applause.) I have great pleasure in moving the re-election of Mr. Allbut as Secretary.

Mr. Pemberton, in seconding the motion, said that Mr. Allbut devoted a great deal of time and energy to the Association, and if they were going to advance as they seemed likely to do, they could not have a better man to carry out those progressive measures than Mr. Allbut. (Hear,hear.)

Mr. Allbut, in returning thanks for his unanimous re-election, and for the honorarium which had been voted him, said that the Association was growing rapidly. It was gaining influence, and many members were going to support it with higher subscriptions. The honorary membership had also increased considerably. In fact, the Association was growing so rapidly that he was afraid the time would soon come when he would not be able to do the work, and they would require to appoint a Secretary who could devote the whole of his time to it.

The Re-Organisation Scheme.

The meeting next took into consideration the recommendation of the Council with regard to annual subscriptions. It was proposed to fix the rates as follows:—Members, £1 1s.; associate members, 10s. 6d.; associates, 3s. The object of the changes, it was explained, was to widen the organisation, give greater facilities to the members and increase efficiency. Among the purposes for which an increase in the funds was required were the publication of proceedings to include fuller reports of the papers and discussions at the annual meetings, papers and discussions at Branch meetings, and abstracts of British, Continental, and American papers or researches relating to foundry practice. Copies of the "Proceedings" are to be supplied to all classes of members, except associates, who, however, will be supplied with them at a reduced price.

Mr. Pilkington, in moving the adoption of the scheme, said that as the author of it in the Council he could assure the meeting that the sole object with which it had been devised was to increase the usefulness and the membership of the Association. The suggestions were very well put forth in the report, but he would just call their attention to the opening sentences. They had to consider whether the payment was sufficiently high to meet their expenses. Up to the present their expenses had come to an average of 7s. 9½d. per member per annum, while the ordinary subscriptions had been 7s. 6d. The expenses over and above the ordinary subscription had been provided out of the guineas of the so-called honorary members. Their endeavour in bringing forward this scheme was to increase not only the membership, but also the status of the Institution. Their desire was to print more literature, to provide more money for propaganda, and to endeavour to get a larger number of members subscribing their guineas. They proposed to do away with the disqualifications which now attached to the members subscribing a guinea. They proposed that these should not be called honorary members, but should be members having the franchise and giving their votes like anyone else. They hoped that a large number of members would subscribe the guinea. The members belonging to the Association who did not belong to Branches they proposed to allow to continue to pay 7s. 6d. if they wished it, though they could pay more if they chose. Those belonging to Branches it was proposed should pay a 10s. 6d. subscription which would cover the Branch expenses. The Birmingham Branch had always been self-supporting, but two Branches, namely, Lancashire and Sheffield, had cost the parent Association 2s. 3d. per head. They had spent a great deal of time discussing this matter, and the report embodied the conclusion which they had arrived at, as the best solution of their difficulties. They required more funds in order to increase their influence and print the Branch papers and other things as it was desirable they should do. The Association was not quite self-supporting at the 7s. 6d. subscription, and he thought it was best while they were an increasing Association and bringing in more members to put its firmness on a sound basis. He moved that the suggestions in the report be adopted.

Mr. Longmuir said he had very great pleasure in seconding the proposition. Mr. Pilkington had shown very clearly the financial aspect of the case, besides the convenience of a proportional arrangement. They had also to consider whether as suggested in the report, they were aiming sufficiently high, and he thought that the scheme set forth in the report would enable them to move in that direction. It was always well to have a high ideal, even though one could not always attain it, and in this case they ought to set their ideal fairly high. They were looking forward to issuing in the future reports of the year's work, containing, in addition to the proceedings of the parent Society, the work done by the Branches. They hoped in this volume to give an abstract of all the more important foundry matters, and of all the important papers read on foundry practice, and so to bring their members into touch not only with British, but also with Continental and American practice. This, of course, was by no means a new thing. Other institutions did it regularly for the particular classes of work for which they catered. They were not venturing on an unknown task. They were simply following a fairly well-marked line, with the idea of bringing their members into touch with the very best and very latest in connection with their particular work. That, of course, was the ideal, and to attain that required a considerable amount of money, as Mr. Pilkington had explained. They hoped that membership of their Association would in the future imply a certain technical distinction. That was another thing they had in view in endeavouring to increase their efficiency.

Mr. Sherburn said that in the unavoidable absence of the President of the Lancashire Branch, he should like to voice the feelings of the Committee of that Branch on this particular point. They had already been told that their Branches were not conducted at present in a uniform manner. While the Birmingham Branch had been self-supporting, owing to the members paying the full subscription, including the 3s. for local members, the Sheffield and the Lancashire Branches were paying on a different system. The Lancashire Branch had not been paying any extra for local membership. That Branch was founded in a different manner, with the result that it had not had any local subscriptions. Thus, they found themselves in an invidious position, and ac-

cordingly a resolution was sent up from the Lancashire Branch requesting that the Branch membership be made uniform as soon as possible. If that uniformity was included in Mr. Pilkington's proposition, the Lancashire Branch would have much pleasure in supporting it.

MR. PILKINGTON: We do propose to pay all the Branch expenses in the future.

MR. SHERBURN: That has not been put in a definite form, so I take it the Council would have to put this in the constitution in a definite form and bring it before the Convention next year.

The PRESIDENT: No! I take it we shall get a definite instruction from this meeting. The proposition is that the members pay a guinea, that the associate members pay 10s. 6d. (that is the subscription for Branch members), and that associates pay 3s. It is proposed, however, to make this exception, that the present members who are not connected with a local Branch may continue to pay 7s. 6d. All the members of the local Branches will pay 10s. 6d., and the whole of the expenses of the Branch meetings will be paid from headquarters. These proposals are definite.

MR. PILKINGTON: That will want to be made a little more definite than it appears at the present time. I therefore embody in the resolution, "That we pay all the Branch expenses from headquarters."

MR. SHERBURN said that the feeling in the Lancashire Branch was that the Branch members were somewhat tied in their expenditure and in the freedom they might have for missionary work in their district, owing to the fact that their expenses were only tentative and, as had been seen, subject to criticism. At any rate, they did not feel that they had sufficient freedom, and therefore the Lancashire Branch thought that a certain proportion of subscriptions should be kept to pay Branch expenses and a definite proportion sent to the parent body. They were, of course, quite willing to waive their own ideas, if a uniform system could be arrived at, which was not likely to cause friction in the future.

MR. BUCHANAN assured the Lancashire Branch that they were quite prepared in Birmingham to be put on the same footing with all the other Branches. (Applause.) They did not expect, and he hoped no other Branch expected, that they were going to run on a loose rein financially without any control. He had been in that happy situation, and his experience was that they needed control. They were quite aware that the Lancashire Branch was in a rather difficult position, and they desired that no other Branch should get into that position. One thing that actuated the Council almost more than anything else in proposing that the finances of the Branches should be administered to a great degree from the centre was their desire to strike out in new directions and form new Branches. It was a difficult matter for two or three enthusiasts to start a new Branch, and probably see before them an outlay, regarding the repayment of which they were not assured. That undoubtedly had been a great difficulty in the way of forming new Branches. They thought that by having all finances coming into the central body, they would be able to found Branches wherever they saw an opportunity.

MR. CARRICK asked what was the minimum number of members to allow a Branch to be organised. The President and Secretary were aware that during the past few months they had been making strenuous efforts to get a Branch formed in Bradford, but not with very much success as yet. He got his firm to have letters type-written and sent to a number of firms in the district. He also got Mr. Buchanan down to help him to organise a Branch, but up to the present they had only got about twelve members. The question was, what constituted the minimum for forming a Branch? Those of them who were not members of a Branch were quite prepared to pay the extra subscription to extend the usefulness of the Association, but they would also like to have Branches in their own locality. He wished to ask the Secretary what the subscription was in America.

MR. LONGMUIR: The subscription to the American Foundrymen's Association is two guineas a year.

The PRESIDENT: And I may add that they are trying to increase it.

MR. CARRICK: What constitutes the minimum number for forming a Branch, and what is the Association prepared to do in case a few members make a special effort to form one?

[At this point the discussion was interrupted by the entrance of the Deputy-Lord Mayor of Birmingham, who gave the Convention a welcome to the city, as will be found recorded below].

On the discussion being resumed, the PRESIDENT said that Birmingham had never felt any grievance with regard to the existing arrangements. The Lancashire Branch, as Mr. Sherburn had stated, was formed in quite an accidental way. It was, in fact, the first Branch to be formed, and the Association then had no rules whatever. Therefore, there was nothing against the Lancashire Branch being formed in that way. The Birmingham Branch felt that they ought not to form a drain on the Society, and therefore they voluntarily agreed to an extra subscription for Branch purposes of 3s. per member. It was quite a voluntary arrangement, and they had never felt that it gave them a grievance against another Branch.

MR. HEGGIE, referring to the associate members, said he would have liked to retain the word member for those who paid 10s. 6d. subscription.

The PRESIDENT replied that they must have some distinction. There was nothing invidious about this distinction. It was quite upon the lines of other societies, which had three rates of payment. Any associate was quite at liberty to apply for membership. He also explained that there are to be guinea members, and then those paying 10s. 6d. as associate members. All the money will go to the parent body, and all the expenses will be paid out of that. The lowest any foreman can pay is 10s. 6d., 3s. being used for the Branches and the rest for the expenses of the parent Society.

MR. PILKINGTON: With regard to the formation of Branches, we shall be happy to help anyone who wishes to form a Branch. We will not only find you the money, but we will find you speakers or readers of papers, and we will make no cast-iron conditions as to how many members should form a Branch to begin with.

MR. SHERBURN: Manchester was formed with seven or eight members.

The PRESIDENT: In Birmingham on the first night only twelve joined, but in a year's time it grew to fifty. (Applause.)

MR. FINCH thought that those who paid 3s. got more benefit than a good many of those who lived at a distance from the Branch centres, and paid 10s. 6d. He suggested that the associates should pay 5s. if the associate members had to pay 10s. 6d.

MR. LONGMUIR pointed out that the associate members would receive the bound volumes of the "Proceedings," which might be worth anything from two to three guineas, whereas the associates would only be privileged to get it at a reduced price.

MR. PILKINGTON said he quite appreciated Mr. Finch's point, but a great many of them thought it undesirable to raise the associate members' subscrip-

tion. They were very anxious to attract to the Branch meetings a class of men who did not attend the Annual Convention, and it would be diplomatic to allow them to continue at 3s.

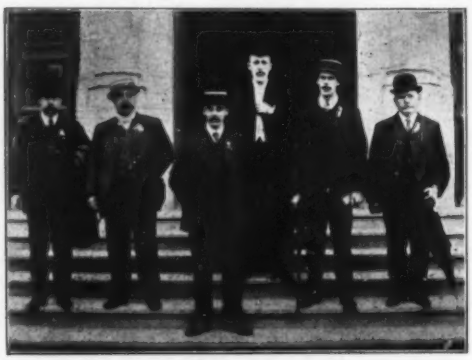
MR. HEGGIE was certain it would be a mistake to raise the subscription of associates. It was understood that this 3s. was for the ordinary workman, and no foreman should pay less than 10s. 6d.

The PRESIDENT then put the motion as amended, with the consent of the mover, and in accordance with Mr. Sherburn's suggestion, and it was carried unanimously.

Civic Welcome.

On the arrival of the Deputy-Lord Mayor (Alderman Sayer), as mentioned previously,

The PRESIDENT said:—Gentlemen, I must defer this discussion for a little while because we now have with us the Deputy-Lord Mayor of Birmingham. (Applause.) We could not have the privilege of having the Lord Mayor himself simply from the fact that he is out of England at the present time. Otherwise, as he assured me, he would have done everything he possibly could to be present. Had he been here, it would have been a unique occasion



A GROUP OF OFFICERS.

Mr. H. Pilkington (Past President); Mr. Charles Jones (Vice-President); Mr. F. J. Cook (President); Professor Turner; Mr. Percy Longmuir (Senior Vice-President); Mr. R. Buchanan (Past President).

from the fact that it would have been the first time we have been received civically by a Lord Mayor directly connected with our own trade. Many of of you know that Sir George Hamilton Kenrick is a member of a large local firm of ironfounders, and takes a very active part in it. In Alderman Sayer, our Deputy-Lord Mayor, who is a well-known and worthy citizen of Birmingham, we have a gentleman who though not directly connected with our own trade has considerable sympathy with it inasmuch he has much to do with metals generally.

The DEPUTY-LORD MAYOR: Mr. President and Gentlemen, the Lord Mayor has requested me to come here to extend to you a most hearty welcome to the city of Birmingham. At the same time, I should like to congratulate your Society, although young, on the progress it has made. It is an educational society pure and simple, and it is to societies of this character we look for the maintenance of our manufacturing position in the markets of the world. The old day of rule-of-thumb is passing away, if it has not already passed away, and this particularly applies to the Foundrymen's Association. It is only within modern days that we have come to recognise that the man who wants to be a master of his craft in the foundry must have a knowledge of metallurgy and chemistry, and must call to his aid the microscope, the spectroscope, and the pyrometer. It has been said, and truly said, that a man to be good enough for his post must be too good for it, or he is not good enough. That applies certainly to your craft. I trust that your educational institution may grow from more to more, for it is only by this means that we shall maintain our position. The future is to be a race between ignorance and skill, and the victory will be to the strong. You have some most excellent papers for your entertainment which I should very much like, had the time permitted and your courtesy allowed, to have remained to listen to. You have also some excursions arranged which will be of an interesting and instructive character, and I wish that your visit may be enjoyable and also profitable. It only remains to you to add to the ranks of your Society to which I wish every success.

The PRESIDENT: Gentlemen, I am sure you have all listened with great attention and profit to the remarks of the Deputy-Lord Mayor. I have therefore the greatest possible pleasure in proposing that we give him a hearty vote of thanks for having graced our proceedings with his presence.

The meeting carried the motion by rising.

The PRESIDENT: Mr. Deputy-Lord Mayor, I have very great pleasure in offering you our hearty thanks for gracing our proceedings and for giving us so much of your valuable time.

The DEPUTY-LORD MAYOR then expressed his pleasure and hoped the time would not be far distant when the Association would visit the city again, and in very largely increased numbers.

The Deputy-Lord Mayor then left the meeting.

A Compliment to Mr. A. H. Hiorns.

MR. R. BUCHANAN said it gave him much pleasure to propose Mr. A. H. Hiorns as a Life Member of the Association. He was a very noted man in the metallurgical world, and had been a particularly good friend of the Birmingham Branch.

MR. P. LONGMUIR said he seconded that proposition. Any member visiting the Birmingham Branch meetings would see the amount of work and the amount of attention given to that Branch by Mr. Hiorns. The local Branch were exceedingly fortunate in having a member of the department in which their meetings were held attending their meetings and using his influence in their favour. Outside Birmingham Mr. Hiorns was exceedingly well known, and he for one claimed to be a student of Mr. Hiorns long before he met him in the flesh. Many who had not had the advantage of listening to him had read his books.

The CHAIRMAN said he had the greatest possible pleasure in supporting the proposal. As one who assisted in the formation of the Association, and as a former secretary of the Birmingham Branch, he knew what a great help Mr. Hiorns had been, not only when the Branch was formed but ever since. The success of the Birmingham Branch was largely due to his efforts and assistance.

The resolution was carried with acclamation.

MR. A. H. HIORNS, in acknowledging the compliment, said the honour had come upon him as a surprise, but he appreciated the compliment, and it had always been a great pleasure to attend the meetings of the Birmingham Branch. At the same time, he had received much more than he had given. They knew the technical teacher suffered considerable inconvenience in not being acquainted with the practical details of an industry carried out on a large scale, and he was always ready to acknowledge that laboratory experiments and experiments in the foun-

dry were two very different things. Large quantities of metal were apt to behave very differently from small quantities in the crucible. He had received a great deal of benefit from the papers and from the discussions by the practical men attending the meetings. He intended always to take great interest in the Birmingham Branch, and to do his best to make it a success. (Applause.)

Election of Council.

The CHAIRMAN announced the result of the ballot for the election of members of the Council as follows:—

W. J. Morris, works manager, Butterley Iron Works, Derby.

C. Heggie, foreman patternmaker, Messrs. J. W. Wright & Eagle Range Company, Aston, Secretary Birmingham Branch.

L. Graham, foreman moulder, Messrs. Willans & Robinson, Limited, Rugby.

W. F. Bagnall, proprietor, Shalesmoor Foundry, Sheffield.

THE CONVENTION IN SESSION; RADICAL LECTURE THEATRE, OLD UNIVERSITY BUILDINGS.

W. J. Ellis, proprietor, Messrs. Flack & Ellis, Southampton.

C. Morehead, foundry manager, Messrs. Siemens Bros. & Company, Limited, Stafford.

The voting had been rather close in regard to the last-named. Mr. Jones, of Coventry, who was not elected, obtained forty votes, while the two in front of him got forty-one.

Presentation to Mr. Pilkington.

The CHAIRMAN said he had a pleasing duty to perform in asking Mr. Pilkington to accept a small token of their esteem and regard for the work done as President of the Association. They knew that a great deal depended in the success of the Association on the President. They were fortunate in having Mr. Buchanan, who was a past-master in the art of occupying the Presidential chair as their first President, and he was followed most ably by Mr. Pilkington, who had also had a large measure of experience, and under his guidance the Association had grown rapidly and done very good work. In asking him to accept an illuminated address, he would like to tell Mr. Pilkington that that was only a small token of their esteem.

MR. H. PILKINGTON, in accepting the gift, said he did not find it easy to talk on that subject, but he very highly appreciated that acknowledgment of his two years' service as President. It had been a rather arduous two years. There had been a great deal of work in re-organisation to be done, and they could not do that sort of thing without coming up against somebody. But they were all now the best of friends and were trying to do what they could for the good of the Association. It was especially suitable that such a presentation should have been made in Birmingham because the Association was born there. He would continue to take the greatest possible interest in the Association which he had very closely at heart.

The address, which was read by the CHAIRMAN, was as follows:—

"To Mr. Herbert Pilkington, M.I.C.E.

"We, the members of the British Foundrymen's Association, desire to place on record our sincere thanks for the valuable services that you, as President, have rendered to us during the two years ending August, 1908. To mark our esteem and appreciation of the ability and initiative displayed by you in the conduct of the affairs of the Association, we have much pleasure in asking your acceptance of this address, and earnestly hope that you may have every happiness and prosperity.

"Signed on behalf of the members,
"F. J. COOK, President,
"PERCY LONGMUIR
"CHARLES JONES,
Vice-Presidents,
"J. E. H. ALLBUT, Hon. Secretary.

"Presented at the Birmingham University, August 2, 1909."

Acknowledgment of Good Service.

MR. H. WINTERTON brought forward what he called a hardy annual in the shape of a vote of thanks to the officers of the Association. The success realised made that thanks something more than a formality. Some sort of criticism, he said, had been offered, but

that would not prevent them from appreciating the hard work done during the year. In the words of a celebrated statesman, that criticism could only be described as a mere "terminological inexactitude." The work of re-organisation had been heavy owing to the rapid growth, and they would see that there was a sum of £103 in the bank, which was a sign of great progress.

MR. MARKLAND seconded, and the resolution was carried with great heartiness and was briefly acknowledged by the PRESIDENT.

MR. MATHER said he would like to point out that nothing had been done to acknowledge the services of one who had borne the heat and burden of the day in years gone by, namely, the Treasurer (Mr. Finch). He was one of the first, if not the first, to start the Association, yet nothing had been done in the way of appreciation.

MR. R. BUCHANAN said he had much pleasure in supporting the proposition that a suitable presentation be made.

The resolution was unanimously carried, the PRESIDENT remarking that that step had been in the minds of many of them, but it was Mr. Finch who did not favour it at the time. It would now be brought before the Council.

The PRESIDENT proceeded to deliver his Presidential address as follows:—

PRESIDENTIAL ADDRESS.

In addressing you for the second time, as President of this Association, let me first thank you for your continued confidence. On the first occasion, I promised to do all I possibly could to further the interests of the Association, and I can only assure you again that that determination is still undiminished. As I assume once more this responsible position, and recognise the great amount of work yet to be accomplished, I fully recognise how dependent I must be on the assistance of members in general, and that of the Council in particular. It has been the happy lot of successive Presidents to have the support of a perfectly loyal and enthusiastic Council. With that continued help, I look forward to the future with every confidence.

Six years ago, the Society was launched, purely as an educational body, and we may say, without the slightest hesitation, that the progress made has more than justified those who called the Society into existence. The results achieved in so short a time have exceeded the fondest expectations of the Society's promoters. Much more, however, still remains to be accomplished in at least three directions. Our first object must be the education of ourselves and those associated with us in every department of foundry work. Something has also to be done in the education of those responsible, either directly or indirectly, for the design of the work which the foundry has to carry out. A third important requirement is the education of those who are placed under our care, the youthful students of foundry work, upon whom will rest in future the responsibility for maintaining the foundry trade of Great Britain in the premier position, where it undoubtedly stands at present.

Some wise words spoken by Gibbon, the historian, seem to have a special application to the education of the foundryman. Gibbon said: "Every person has two educations; one which he receives from others, and one, more important, which he gives himself." This Association can be of the greatest value in assisting the kind of self-education to which Gibbon refers, and every member should determine to use that help afforded by the reading and discussion of papers at the annual and Branch meetings, as well as by the exchange of views and opinions amongst members, and in the encouragement given to the study of metallurgy. To the technical knowledge acquired in various ways must be added the cultivation of a keen faculty of observation. It is obvious that many discoveries have yet to be made and much detailed information to be secured solely through observation.

A word or two may be said with regard to the education of designers, whose duty it is to specify precisely the work required from the foundry, and who are responsible for the character and general lines of the machinery called for. Certainly the designer is as much in need of training as the foundryman. If the original design is inherently faulty, the best of workmanship will not produce a satisfactory result, and it is equally useless and unfair in such cases to blame the workman. In particular, something further is required in the training of the draughtsman. As a rule, the boy entering the drawing office is the boy who has done well at a public secondary school, and desires an occupation rather above that of the ordinary workman. He goes at once into the drawing office to learn to draw; he seldom or never has any direct intercourse with the workshops, and is, therefore, ignorant of the ordinary routine work of the department of actual production. He may have been diligent in picking up knowledge at the technical school with regard to mechanics, mathematics, etc., but he knows nothing of metallurgy or the practical work of the foundry or the pattern shop, or, indeed, of metals generally. The result is that his designs are often merely fine specimens of misapplied ingenuity. I assure you, these remarks are made in no carping or personal spirit, but with the object of directing attention to what I believe is a question of great importance. A fact frequently commented upon is the general success of American designs. While transatlantic machines are pleasing to the eye, and doubtless suitable and adequate for the work they have to perform, they are produced with a view to the lowest expenditure, both in the pattern-shops and the foundry, in respect to the time expended in moulding and the amount of material to be used. This result, I believe is undoubtedly due to the large interest which American engineers generally take in the foundry and the allied departments, and the assistance which the engineer gets from the numerous technical colleges which are such a feature in America.

In Great Britain we are just beginning to see the importance of practical up-to-date teaching in regard to foundry and kindred subjects. We have one or two instances of universities and technical schools giving instruction on practical foundry matters; but unfortunately the methods so far adopted are far from being effective. One large educational centre is equipped with a foundry, but is not under the charge of a metallurgist, being controlled instead by the head of the engineering department, while a further defect is that the students are not necessarily included among those who take the metallurgical course. Apparently, the sole function of this department is to be to provide castings for the engineering students to work upon. Let it be understood that I do not depreciate the amount of education the student will get from the production of fine and small castings, but I fear that the student is likely to prove the truth of the adage about a little knowledge being a dangerous thing, and when he emerges into practical life, he is quite likely to find that the knowledge he has acquired is of very little use to him. What I would like to see in such an establishment is the taking up of problems of everyday importance for the purpose of thorough research work, and I would not mind if a student never made a mould, provided he watched operations with a lively interest in the

solution of the problem. For example, an enquiry of the utmost importance, and one which would be of valuable assistance in after life, would be a careful study as to the effect of design upon the structure of the metal of a casting. Such a course, on simple lines, could be easily arranged, and its effect would be to implant in the mind of the student clearly defined ideas as to what designs to avoid, and also the lines upon which he should go in order to ensure successful results. It is not to be expected, of course, that the teachers and professors in charge of those establishments can be up-to-date in practical foundry work; but there is no reason why in large and important engineering centres, having ample facilities for this class of work, a committee should not be formed, consisting jointly of teachers and practical foundrymen, who could combine their energies in the framing from time to time of a syllabus of work likely to be of practical use.

The training of the juniors placed under our care constitutes another most important responsibility deserving of careful consideration. Our foundries are recruited largely from the ranks of the average schoolboy, who leaves school finally at fourteen, and it is a question worth considering whether the concluding period of this schooling could not to some extent be utilised as special preparation for his own line of work, especially for boys leaving school at thirteen. There might, during the last year, be some form of compulsory attendance at a technical school on one or two afternoons in the week, where he could be taught something directly applicable to the scientific side of the trade he is selecting, which, in this case, would be the foundry. The results would be better, while the system would cost no more than at present.

It seems to me that the Birmingham jewellers have come nearest to solving the problem of technical education. They have a system under which youths entering their employ are required to attend at the Jewellers' Art School for two afternoons in the week, where they learn drawing and practical metal-work, the Jewellers' Association compensating, by a system of scholarships, for the loss of time and wages involved by their attendance. At the same time, they provide a youthful labour reserve by allowing boys from the elementary schools, as a reward for ability and good conduct, to spend some time at the Jewellers School on certain afternoons in the week. From these boys the jewellers are able to draw recruits, thus enabling the Institution to become at once, not only an educational centre, but a kind of convenient labour bureau. There seems to be no reason why some such system in a great engineering centre like Birmingham could not be applied to the various foundries of the city and neighbourhood. The pupil would be enormously stimulated to effort by the sense of power which comes from knowledge, and the employer would speedily find the value of the technical training given.

At present the class of boy generally attracted to the foundry, especially in large centres, is the one who has not done very well at school. He thus commences industrial life doubly handicapped, first by his incomplete education, and second by his lack of appetite for further knowledge. Frequently, he has no desire to attend any classes in metallurgy which are available. Judging our educational system by its products, on the principle that "the trade is known by its fruits," the return is not adequate for the money and effort expended.

Equally from the social and industrial points of view, we want to form a higher estimate of the importance of that youthful period which follows the completion of school life. Hugh Miller, the famous geologist, in his book on "My Schools and Schoolmasters," says:—

"The destiny in life of the skilled mechanic is much more influenced by his second education—that of his apprenticeship—than by his first—that of the school; and yet it is to the education of the school that the importance is generally regarded as attaching, and we never hear of the other. The careless, incompetent, scholar has many opportunities of recovering himself; the careless, incompetent apprentice, who either fails to serve out his regular time, or who, though he fulfils his term is discharged an inferior workman, has very few; and, further, nothing can be more certain than that inferiority as a workman bears much more disastrously on the condition of the mechanic than inferiority as a scholar. Unable to maintain his place among brother journeymen or to render himself worthy of the average wages of his craft, the ill-taught mechanic falls out of regular employment, subsists precariously for a time on occasional jobs, and, either forming idle habits, becomes a vagabond tramper, or, getting into the toils of some rapacious task master, becomes an enslaved 'sweater.' For one workman injured by neglect of his school education, there are scores ruined by neglect of their apprenticeship education."

GROUP TAKEN AT THE NEW UNIVERSITY BUILDINGS, BOURNBROOK.

It should be our care in the interests, both of the trade and the students of practical foundry work, to see that they make the most of the period of youthful training passed in our workshops. The special vocation of the Foundryman's Association is to produce that alertness of mind and that spirit of continuous investigation which enables the aspiring foundryman to make continual progress. I believe that the average British moulder is second to none in the world, but, if we are to maintain the premier position, we must produce a class of still abler workmen, and strict attention must be paid to the broad, general education of those whose business it will be to initiate, control, and carry out the work of that department of engineering production to which we belong, and of which we are justly proud.

Mr. Percy Longmuir proposed a hearty vote of thanks to the President for his admirable address.

Professor Turner, in seconding, said the address was most thoughtful and extremely suggestive, showing not only wide knowledge, but considerable sympathy with the young people with whom the President came into contact. If those ideas were put into practice it would be beneficial to the trade generally.

The vote was carried with heartiness.

The President, in acknowledging it, said that he felt very strongly with regard to those matters emphasised in the paper, and they ought not to be behind in their educational system.

Mr. R. Buchanan remarked that in Scotland a system was now in operation under which lads under seventeen might be compelled to attend night schools.

TWENTY-FIVE YEARS OF CAST-IRON.

Professor T. Turner,* M.Sc., Assoc.R.S.M., F.I.C., Birmingham, read the following paper on "Twenty-five Years of Cast Iron."

The subject of the present address is suggested by the circumstances under which we meet. Less than a month ago, their Most Gracious Majesties, the King and Queen, opened the new University buildings at Edgbaston. During the past eight years building operations, on a large scale, have been in continuous progress on the site at Edgbaston, near Bournbrook, and to-day we meet in the old Mason building of the University amid evidences of the busy hand of the contractor. Mason College, as it is still often called, has long been overcrowded, and the class-rooms and laboratories, formerly occupied by chemistry and physics, now no longer required for their original purpose, are being transformed so as to provide accommodation for instruction in other subjects, which must perforce remain in the old buildings for some time to come. One result of these alterations will be to remove all traces of the old metallurgical department of Mason College. This department was familiar to a considerable number of the original members of the British Foundrymen's Association, some of whom actually worked in the old laboratories, while a larger number attended lectures from time to time. In this laboratory, researches were conducted which have proved of general interest to foundrymen, and from the department emanated numerous papers which, in the then less perfect state of our knowledge, were eagerly read by those interested in cast-iron all over the world.

The first paper of the long series to whch I have referred was published in July, 1884, in the "Journal" of the Chemical Society, London, so that it is almost exactly 25 years since the metallurgical publications of Mason College began. It is my desire in this address to give a brief outline of the state of our knowledge in relation to cast-iron at the time of which I speak, and then to present a brief summary of the work which has been done upon cast iron in Birmingham during the interval. It may, however, be well to make two preliminary observations. In the first place, it should be pointed out that the work of the metallurgical department, though best known to foundrymen for its bearing upon cast-iron, is by no means confined to one metal, or to one subject; but on the present occasion references to other subjects of investigation will be omitted, not because they are considered as being of less scientific value, but because they are less suitable for this Association. Secondly, the nature of the task which is being undertaken makes

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it inevitable that attention will be almost exclusively directed to what has been accomplished here. It must not, therefore, be assumed that the work of other experiments or authors is unrecognised, or that the debt of gratitude the metallurgical world owes to such men as Abel, Gautier, Keeu, Ledebur, Moldenke, Stead, and Wood is not fully appreciated.

Turning now to the state of metallurgical knowledge in connection with cast-iron a quarter of a century ago, it may be observed that the more general application of accurate chemical analysis to metallurgical processes dates from the foundation of the Royal School of Mines in 1851, and in 1856 a very important series of chemical analyses and mechanical tests of cast-iron was commenced at Woolwich Arsenal by Mr. J. Spiller, one of Dr. Percy's early students. These experiments were under the general direction of Mr. (afterwards Sir

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Frederick) Abel, and the results were published in a blue book in 1858. The introduction of the Bessemer process for steel-making at about the same time gave a great impetus to the work of the analytical chemist. The result was that analyses multiplied, but as the chemist was dealing with six variables, viz., graphitic carbon, combined carbon, silicon, sulphur, phosphorus, and manganese, the effect of no one of which was accurately known, it followed that the advice of the chemist was of little value, and was, indeed, very frequently misleading. The position was admirably expressed by Dr. Percy in his Presidential Address to the Iron and Steel Institute in 1885, in the following language :—

"It is not many years since we had to grope about to discover an analysis of iron ore or of pig-iron, whereas now we are actually overwhelmed with analyses. We are deluged with percentages of carbon, graphitic or combined, of silicon and manganese, of sulphur and phosphorus. We are bewildered with the vast accumulation of materials, like the traveller in the mazes of a primeval American forest. What is now wanted is the man to reduce it to law and order, to evolve from it principles for our sure guidance."

It will thus be seen that analyses had failed to yield that information which the practical man desired, and this failure was due, not to the errors of analysis, but to the want of information which was necessary in order to rightly interpret the analytical results obtained. It appeared, therefore, that the proper method of attack was by synthesis, or, in other words, to prepare a series of irons in which one element was caused to increase by definite steps, while all the other constituents were kept as nearly as possible in normal and constant proportions. To carry out such a scheme fully would evidently involve an enormous expenditure of time and labour, and the question had to be decided which element was likely to lead to more immediate results, and to give the greatest information. The choice fell upon silicon, and events proved the selection to have been a most fortunate one. The reasons for this selection are worthy of record here. In the first place, Sir W. Roberts-Austen, in his lectures at the Royal School of Mines, had drawn attention to the pressing importance of obtaining definite information as to the effect produced by silicon in iron and steel; and, secondly, I found on coming to Birmingham that my chief, Dr. Tilden, was already interested in the question as to the condition in which silicon existed in cast-iron, and that he warmly approved of a suggested research on the synthetical lines above indicated. A plan of work was at once outlined, which took five years to complete, and which was only at length accomplished with the aid of Sir Robert Hadfield, Mr. F. W. Harbord, Sir A. B. W. Kennedy, Mr. J. P. Walton, and others. The proposal was to divide the research into three parts, and deal separately with the influence of silicon on mild steel, on crucible steel, and on cast iron respectively Experiments on the first part of the subject were by the kindness of Mr. F. H. Lloyd, commenced with an acid Siemens' furnace at James Bridge, but were abandoned after a few months, largely because the time required at the works to conduct experiments interfered with my duties at Mason College. Experiments conducted with steel in the College, with the appliances at my disposal, always led to failure, as I could not pour a sufficiently large charge of metal. This part of the subject was, therefore, deferred for some three years, and was afterwards completed at the works of the Staffordshire Steel and Ingot Iron Company, Limited, at Bilston, with fluid metal from the basic Bessemer converter. The portion of the subject relating to silicon in crucible steel could not be carried out in our laboratory, for reasons similar to those previously mentioned, so Mr. (now Sir Robert) Hadfield was asked to undertake these tests at Sheffield. With this request he readily complied, and the results of Mr. Hadfield's researches were separately published. A complete series of samples illustrating the ingots prepared in these experiments were presented to Mason College, and may be seen in the Metallurgical Museum at Edgbaston. The first research undertaken, was, therefore, that relating to the influence of silicon on the properties of cast-iron, the objects being to prepare a series of test bars of a standard and commercial size from a series of mixtures in which silicon was the only varient. At present, this is tolerably easy, as "wasned iron" forms an excellent base, while ferro-silicons can readily be purchased with upwards of 50 per cent. silicon, and silicon is itself commercially obtainable. But in 1883, the highest ferro-silicon, not rich in manganese, which was made in the blast furnace, contained about 10 per cent. of silicon. Even this metal contained nearly 2 per cent. of manganese, and some months were spent in a preliminary attempt to remove the manganese without eliminating the silicon. It was proved that by all the methods examined, the silicon and manganese were oxidised together, and ultimately the idea of purification was abandoned. A further difficulty arose from the fact that, with 10 per cent. of silicon, the maximum proportion of carbon which the iron can take up and retain is about 2 per cent., and hence it became evident that one end of the series must of necessity have only 2 per cent. of carbon, instead of 3 or 3.5 per cent., as in ordinary cast iron. Two alternatives suggested themselves : either to saturate each melt with carbon and so pass gradually down the series from 3.5 per cent. at the one end to 2 per cent. at the other, or to prepare a base free from silicon, but with 2 per cent. of carbon. The latter procedure was selected, and "pure cast-iron" was made by heating wrought iron in crucibles with charcoal. The product was white cast-iron, containing about 2 per cent, of carbon, 0.19 per cent. of silicon, 0.32 per cent. phosphorus, 0.14 per cent. manganese, and 0.05 per cent. of sulphur. The test pieces employed were round bars $1\frac{1}{2}$ in. in diameter, and about 20 in. in length over-all, so as to allow of a clear foot in the middle of the bar for accurate measurements. The tests included tensile strength, crushing strength, density, and hardness; while observations were also made upon the relative fluidity, smoothness of surface, shrinkage in the mould, and character of fracture. The transverse strength was also calculated. A full account of the results obtained have been summarised in my "Metallurgy of Iron," and anyone interested may find further particulars in the original papers.

Perhaps the most important observation was that metal with less than 1 per cent. of silicon was white, hard, and brittle; it possessed a rough surface, contracted considerably in the mould, and generally was full of blow-holes. It was, therefore, quite unsuited for the ordinary work of an ironfoundry. With about 1 per cent. of silicon the metal was sound, and had a high crushing strength, but was too hard to turn or machine. With from 1.5 per cent. to 2.5 per cent. of silicon the metal was soft, sound, and grey; while the maximum tensile strength was obtained with rather less than 2 per cent. of silicon. With such silicon content, the metal was admirably suited to all the usual requirements of the foundry, but for greater fluidity more silicon was found advantageous, though the metal suffered in strength

by such addition. With still higher silicon the metal became weak and brittle, while the hardness at the same time also increased somewhat.

It was pointed out that the effect of silicon on cast iron was two-fold; first, that due to the silicon itself, and, secondly, that resulting from its influence on the carbon present. The first effect is of a more uniform, but less definite, character, and is similar in kind to that of any other element which unites with iron to form a solid solution, viz., the production of a material with greater tenacity, increased hardness, less ductility, and usually also a lower melting point than that of pure iron. In this connection, the elements may be said broadly to differ among each other, not so much in the nature or character of the effect which they produce as in the amount or quantity of that effect and the proportion of the added element which is needed in order to obtain the maximum benefit. It is also important to observe that the different properties of the metal, though usually altered in the same general direction by the addition of a foreign element, are not all altered in the same proportion. For example, both carbon and nickel increase the tenacity and hardness of iron and reduce its ductility. But since the ductility is diminished much more rapidly by carbon than by nickel it is advantageous to use nickel when combined tenacity and ductility are desired. Many similar examples could be readily supplied, and it is doubtless to some kindred action that part of the beneficial influence of silicon is due. Silicon also has a profound influence on the carbon which is present in cast-iron. The carbon which is retained in solution in the iron during and after the solidification of the metal makes the iron hard and brittle, but if this carbon, having been thrown out of solution exists in the free or graphitic form the iron is too soft and tough. Now, silicon dissolves quite readily in iron, in the form of silicide, and while the limit of solubility of carbon in iron is about 4.25 per cent. there is no limit to the solubility of silicon. It would appear that silicide of iron does not dissolve carbon or dissolves it only to a very slight extent, hence in iron which already contains silicon the solubility of carbon is diminished, so that the total carbon present becomes less and less as the silicon increases. But the most marked effect of silicon is that which occurs with almost dramatic suddenness in the neighbourhood of 1 per cent. silicon. Here the carbon which was originally dissolved in the fluid cast-iron is thrown out of solution during the solidification and subsequent cooling of metal, and a white, hard material is transformed into a casting which is soft and grey. As is well-known the actual proportion of silicon which is necessary in order to produce this truly wonderful change will vary according to the proportion of other elements and the rate of cooling. In ordinary practice, the rate of cooling is largely determined by the size of the casting, and hence for small castings more silicon should be added. We may here also so far anticipate later work as to mention that in grey cast iron which contains silicon the second arrest in the rate of cooling which is observed in steel and in white cast iron in the neighbourhood of 680 degrees is appreciably raised by each addition of silicon. In other words, silicon accelerates the formation of pearlite, and probably also its decomposition, and hence under suitable conditions leads to the production of finely divided or amorphous graphite. But at the time of which we are now speaking, viz., 1885, Sorby's paper on the application of high powers of the microscope to iron and steel was still unwritten, and the Le Chatelier thermo-couple had not yet found its way into the laboratory of the metallurgist. Hence observations on micro-structure and on arrest points were delayed for more than a dozen years.

As is usual when pursuing a main line of investigation, numerous side issues claimed attention from time to time, and a few words in relation to some of these may not be out of place. Two papers were published about this time dealing with a comparison of certain methods adopted for estimating silicon in iron and steel, an estimation which was obviously of primary importance in connection with such a research. The subject of the hardness of metals was also carefully studied on account of the importance of soft cast iron to the ironfounder, and an instrument called the sclerometer was introduced for determining relative hardness by means of scratches produced with a weighted diamond. Other methods have since been found more convenient in works' practice, but the sclerometer has also served a useful purpose, and was specially designed in connection with the silicon researches.

The estimation of carbon in iron and steel was not so well understood or so regularly conducted in those days as at present, hence a comparison of the usual processes was undertaken and a simple form of apparatus introduced so as to permit an accurate determination to be performed on an ordinary working bench working any special combustion furnace or transference of the separated carbon. This method is still used in a considerable number of ironworks, especially where the number of estimations required is not large. For total carbon the usual method nowadays is direct combustion, and hence filtration processes are not so much used, but for graphite the method above mentioned is still among the most convenient and most generally adopted process.

The immediate result of the knowledge gained of the effect produced by various proportions of silicon and indirectly also of the influence of combined and graphitic carbon, was that many analyses, which had already been published, could be arranged and compared in order to determine the effect of phosphorus, of manganese and of sulphur. In particular, the analyses of cast iron for cannon, published in a Government Blue Book in 1858, were arranged in various series, in which one other elements was tolerably constant, while the silicon varied. Hence it was concluded that the strongest and most trustworthy cast iron was not that which contained very exceptionally small proportions of phosphorus, manganese or sulphur, but that each of these elements, in suitable but different proportions, appeared to be beneficial. The main conclusions arrived at from these considerations were shortly afterwards confirmed by Mr. W. K. Keep, of Detroit, who, by methods which are well-known now, studied the influence upon cast iron of silicon, phosphorus, sulphur, aluminium, and certain other elements.

Before dealing with the practical applications of these researches, mention may be made of several other investigations made at this period. There was at the time, considerable difference of opinion as to the condition in which silicon exists in cast iron. Many metallurgists of repute favoured the view that silicon, like carbon, existed in two forms, the graphitic and combined. Dr. Tilden's experiments had led to a negative conclusion so far as graphitic silicon was concerned. The question was of great importance, because if silicon really did exist in two separate forms, it was necessary to separately determine the effect of each. In conjunction with one of my students, Mr. A. E. Jordon, a research was conducted, and a considerable number of samples with varying percentages of silicon were examined by mechanical, magnetic and chemical methods, with

the object of separating graphitic silicon if such were ever present. The result of the experiments was briefly stated in April, 1886, as follows:—

"Silicon exists in cast iron in the form of a silicide (or silicides), which is dissolved when fluid in the excess of iron present." Hence it was useless to attempt to estimate the influence of silicon in two forms, and this conclusion has since been amply confirmed, and is now generally accepted. It had long been known that iron which was re-melted was somewhat changed during the process and that it usually became harder and stronger in consequence. Elaborate experiments had been performed in which iron was remelted many times, or kept in the fluid state for lengthened periods with the object of ascertaining the cause of the improvement which was observed. No general rule or principle had yet been observed, and the difficulty was rendered greater by some misleading analyses which had been performed in connection with a series of tests conducted by Sir W. Fairbairn, and which had been widely published. Originally, I was mislead by these figures myself, but fortunately Professor Unwin had preserved samples of the original test bars and these were analysed in Mason College, and checked by Mr. Walton, with the result that the theory of what takes place during remelting of cast iron was made quite plain. It was shown that with each melting silicon is removed while sulphur is added; the effect of these changes is to convert graphitic carbon into combined carbon, and hence to harden the iron.

The experiments previously mentioned had afforded a standard for each of the elements which ordinarily occur in cast iron, but it yet remained to show that results obtained in actual practice agreed with the tests conducted upon a relatively small scale. The first step in this direction was the examination of analyses of specially excellent material from published sources, and also the collecting of specially good cast iron from friends, and analysing the material so obtained. Among others who at the time supplied me with samples of specially strong cast iron mention should be made of Mr. Robert Buchanan, then of Dumbarton, and afterwards first President of this Association. The result of the analyses and comparisons was to show that the proportions of combined carbon, silicon, sulphur, manganese, and phosphorus did not vary over any wide range in any of these specially selected and excellent samples. Another obvious method of putting the theories into practice was to actually make mixtures in the foundry in accordance with the suggested analyses. Fortunately, several opportunities of so doing this soon presented themselves in foundries in connection with which I was consulted. I remember one instance which occurred in 1886, and to which I always look back with some amusement. At the foundry in question silicious pig-iron had never been purchased until these experiments were commenced and was looked upon with great disfavour. I arranged to keep the other elements in the charge as nearly as possibly constant, but by varying the silicon to make hard metal the first day, a soft metal the second, and a typically good iron the third. The charges came out as arranged and desired, but I still smile at the recollection of the faces of the managing director and the foreman, when, on the second day I enquired whether the first day's charge had come out hard as arranged. It appeared that some of the work had been already given out in the engineering shops. I gathered that the language there employed would not all be found in a standard English dictionary, but that when translated it meant and expressed a fervent hopethat such iron would not be made again.

The interest taken in cast iron at this time and during the next few years was truly remarkable, and was not confined to any one part of the British Islands, or to any single country. The work of Mr. Stead, and of the late Mr. Charles Wood, of Middlesbrough, calls for special mention. At the Glasgow meeting of the Iron and Steel Institute, in 1885, these authors gave particulars of the practical results of adding silicious iron in the foundry for softening purposes, and showed that very satisfactory castings were made at a reduced cost, over a period of three months, in a foundry which produced about 60 to 70 tons per day.

M. Gautier did much to interest the French ironfounders in the subject, while Ledebur was a leading German authority, and Keep was doing brilliant work in America. My own correspondence included inquiries from almost every civilised country throughout the world. This widespread interest was the more remarkable, because cast iron had already been superseded as a material for construction; the success of the Bessemer, the Siemens, and the basic processes was fully assured, while America and Germany were rapidly increasing their production of steel. The renewed and extended interest in cast iron came as a surprise to those who believed the days of the ironfounder to be numbered, and was a revival which was as unexpected as it was pronounced.

Ironfounders now began to feel the necessity for more scientific knowledge, and of the opportunity of meeting together to discuss their difficulties and to exchange experiences. The formation of the American Foundrymen's Association may be said to have marked a new era in foundry work, and many successful meetings have been held and much information imparted to the world by this important Association during its, as yet, relatively short existence. Our own British Foundrymen's Association is even yet more juvenile, though it has already done much and is doubtless destined to do very much more, for those who are interested in the casting of iron. In all branches of industry, and no less in ironfounding, scientific and technical knowledge is becoming increasingly important, and while the proper training of the younger generation in our schools and colleges must be naturally the first step, such training appears to render even more necessary the more effective work of scientific and technical associations for men of more mature age.

Returning now to the story of scientific discovery, it may be pointed out that this, in cast iron, followed the general lines which had been adopted with wrought iron and steel. The general order may be stated as being first mechanical, secondly chemical, and, thirdly physical. The experiments hitherto recorded dealt with the mechanical and chemical properties of the material, but the microscope and the pyrometer had yet to be employed. Between 1893 and 1902 tentative work in this direction was undertaken by the late Mr. Walter MacMillan, at Mason College, and Royston's researches on malleable cast iron indicated that some good work was done, but it was not until after the University was established in 1900 that proper equipment was available for such investigations. The researches of Sorby, Roberts-Austen, Arnold, and Stead, had dealt with steel, but cast iron had only been incidentally touched, and no attempt had been made, so far as I am aware, to connect microstructure with suitability for the many varied uses of the ironfounder. Two important observations had been made, however, to which it is necessary to refer, even though this leads to another digression from the story of the work done in Birmingham. The first of these was the late Professor Ledebur, who, in 1889, had called attention to the fact that the graphite in cast iron is of two kinds

one of which is in flakes and the other in fine powder. These are now usually called primary and secondary graphite, respectively, and Ledebur showed that the latter variety is that which occurs in annealed malleable cast iron. The other investigation in 1900 was conducted by Mr. Stead, and dealt with phosphorus in iron and steel. So far as cast iron is concerned, the most important conclusions were that phosphorus exists in iron in the form of a phosphide Fe_3P, which in carbonless iron is in the form of a solid solution, and is, therefore, not visible under the microscope. But in grey cast iron the phosphorus separates as a eutectic of iron and phosphide of iron, and this separated material is more fusible than the rest of the metal, and can be readily seen under the microscope. The recognition of two forms of free carbon and of a phosphide eutectic in cast iron were of the utmost value in connection with the microscopic and thermal properties of the metal. The possession of a considerable number of samples of cast iron of known chemical and mechanical properties rendered the microscopical examination more systematic and more valuable, especially as the work was in the hands of one so painstaking and skilful as my colleague, Mr. O. F. Hudson. It was soon recognised that all hard cast irons contained cementite, while weak and soft cast irons contained graphite in a state of coarse division. The proportion of phosphorus can be roughly estimated in grey irons from their microstructure, and all soft, strong, grey irons give a close-grained, even structure, with relatively small graphite and no large areas of phosphide eutectic. A considerable number of micro-photographs, prepared by Mr. Hudson, and illustrating these facts, have been published, and it is now easy in the majority of cases to predict many of the properties of a casting after a brief inspection of a micro-section. Another method of attacking the questions, which, however, was much more tedious, but which confirmed the deductions obtained by the microscope, was the separation by chemical processes of pure graphite from samples of cast iron, and then by the mechanical process of sieving to separate the graphite into various portions, such as coarse, medium, fine, and very fine. By weighing each portion separately it was found that in cases where the proportion of graphite was large, the metal was soft and weak, while conversely, strong irons usually give a large percentage of finely divided graphite.

More recent work of an interesting character had reference to the volume and other changes of cast iron during and after solidification from the fluid state. There was at one time considerable discussion, with which the name of Mallet is associated, as to whether or not cast iron expanded during solidification. My attention had also been drawn to the fact that when iron is cast in chills the metal often cracks during the process of solidification and subsequent cooling, but that such fractures can be largely prevented if the mould is removed while the casting is still red hot, and the metal is thus allowed to cool normally to the ordinary temperature. This fact indicated a critical point in cast-iron similar to those which had already been observed in the case of steel. The first accurate observations on the volume changes of cast-iron were made by Mr. Keep, and it was shown that in some irons three distinct arrests in the rate of contraction or even three actual expansions took place while the metal was passing from the fluid state to a dull or scarcely visible heat. The enquiry which was thus in a very interesting stage, was then taken up at the University of Birmingham, and tests were made with irons of varying compositions, by means of the extensometer and also with the pyrometer during the same intervals of time The reason for much of the uncertainty which had existed in reference to the expansion of cast iron during solidification was then made clear. It is now well known that most metals contract uniformly during solidification and show no irregularities during subsequent cooling. White iron closely resembles these metals, since it shows only one relatively small temperature arrest, and an almost negligible arrest in contraction during cooling. This single arrest occurs at slightly under 700 degrees. Hence white cast iron does not appreciably expand during solidification, and the result is the well known fact that a greater allowance must be made in the pattern for a hard than for a soft iron. With grey hematite iron two very marked expansions are observed, while if phosphorus be present in addition to silicon there are three distinct expansions and three separate temperature arrests. The arrest due to phosphorus is in the vicinity of 900 degrees, while that which occurs in the neighbourhood of 700 degrees is somewhat raised and becomes much more pronounced in the presence of silicon. The presence of a small proportion of manganese appears to make this arrest and expansion still more marked, but this point is now under further investigation. With a suitable apparatus these expansions are very definite and readily observed, and they doubtless explain why soft irons contract less in the mould than harder metal. What we ultimately observe as a change of volume in the finished casting is in reality the resultant of at least four separate actions, namely, the continuous and regular negative volume change corresponding to that of a uniform material, minus three positive changes due to the separation from that material of primary graphite or phosphide eutectic, and of secondary graphite (or of pearlite), respectively. These observations emphasise the importance of suitable heat treatment of cast iron after it is poured into the mould. Though chemical composition is of great importance, analysis is only one aid to the scientific ironfounder. If he is to succeed he must also know how the metal is affected by each element which is present, and how the ultimate mechanical properties are influenced by the many and varying physical conditions through which the material has to pass.

This rapid survey of the progress of science as applied to cast iron, during the past quarter of a century, is naturally incomplete and onesided. It will, however, perhaps serve to call attention to what has been accomplished. While the founder formerly relied merely upon accumulated experience of brands and numbers, and did not know the suitable proportion or the characteristic influence of the various elements which are present, he now knows with considerable accuracy, the effect of every usual constituent. The condition in which each element occurs is also well known, and the alterations which take place during remelting are clearly understood. Much light has also been thrown upon the changes which occur while the metal is solidifying in the mould, and the microscope has been applied so as to give a whole range of useful information as to the character and properties of the finished article. Remarkable as have thus been the increases of knowledge during the past quarter of a century it must not be supposed that all has yet been discovered, or that any finality has been reached. In many directions we are as yet only in the gateway of knowledge, and for the young and energetic investigator who has the requisite training and skill the field is as wide as ever before. Rather, it should be said, it is wider, for every firm foundation securely laid is but a stone on which to build, and through each doorway, which has now been

opened, the earnest student sees long corridors as yet untrod.

Discussion.

The PRESIDENT said that they would all agree that Professor Turner had given them an interesting and valuable historical survey of the great work that had been done in that Institution for the benefit of iron-founders. It would be interesting and beneficial to them in several directions. It gave them an outline of how experiments in the past had been conducted, and would probably suggest ways of experimenting for themselves in other directions. They would also by means of that paper be able to look very closely into the results that had been achieved. As an historical survey the paper did not lend itself much to discussion, being mainly an announcement of facts.

MR. A. H. HIORNS remarked that what he might call the classical experiments of Professor Turner, of twenty-five years ago, had led to enormous and very important results. Professor Turner might rightly claim to have been the first to bring before the notice of iron founders the very important influence of silicon upon cast iron. His very early results were obtained with a very limited apparatus. He had no microscope or pyrometer to speak of in those days. It had been to himself (the speaker) a matter of surprise that the Professor had been able to do so much with so little apparatus. Similarly, Faraday was able to predict with very simple appliances the vast present-day uses of electricity. Professor Turner would not claim that his experiments were perfectly exact, or that there was any finality about them. With regard to the action of silicon, it was only under certain conditions that the results occurred which the Professor brought out. Under other conditions the silicon was apt to operate in an opposite direction. They must have with fairly high silicon perfectly white cast iron. They had to take into consideration conditions of heat treatment.

MR. H. PILKINGTON congratulated Professor Turner on his excellent historical sketch, which constituted rather a text-book than a paper, and would prove valuable to the members on account of the amount of information conveyed. He was glad to notice the emphasis laid on the importance of suitable heat treatment, and the remark that while chemical composition is of very great importance, analysis is only one aid to the scientific ironfounder. Probably Professor Turner would recall that twenty-two years ago, when he (Mr. Pilkington) made a similar observation at the South Staffordshire Institute, the reception by the chemists was not kindly. Respecting Charles Wood, of Middlesbrough, he was the first man who made practical use of the silicon in regard to castings, although he was not the originator of the idea. Others had practised the use of silky or glazed iron before him, and following chemical analysis fine graphite was aimed for at South Staffordshire long before this date. In 1889 it was known in a scientific way to the trade and its production was attempted. With regard to the two forms of silicon in pig-iron, there was only supposed to be one form of silicon in cast iron, and that was in solution. The question was, what caused the glazed or silky fracture of sulphur pig-iron?

MR. P. LONGMUIR said that Professor Turner was the first man to lay the foundation of scientific foundry practice, and his silicon results had opened up an extensive field, while a good many foremen had taken advantage of those results. Professor Turner could congratulate himself that his silicon paper of twenty years ago was in practically all essentials true to-day, and he ventured to say that could not be claimed for a great many researches. Those silicon results, as originally published, were capable of application in ordinary foundry work at present. The experience gained since their publication had simply confirmed those results. He was quite aware that in one paper, read before the Iron and Steel Institute by Mr. W. H. Hatfield, those results were questioned, but against that he could put a little personal experience. Years ago, when he was a comparatively raw student, certain things were more or less forced upon him, and he had to go very closely into the question of scientific iron founding, especially in regard to the control of cupola mixtures. Professor Turner's book was just out, and those original papers offered the solution of the difficulties and troubles which then appeared. Under ordinary conditions silicon control was exceedingly valuable to the founder. With regard to Mr. Hatfield's results that investigator worked with very small bars, and none of his results were concordant. The only conclusion he reached was that iron was an exceedingly erratic material. Many of them could have told him that without doing any exhaustive research. (Laughter.) That conclusion showed that, unlike Professor Turner, Mr. Hatfield had not eliminated all his variables, leaving only one variable for investigation. Towards the conclusion of Professor Turner's well-known work on expansion and contraction, the remarks on the changes that occur during solidification were of considerable importance. The whole subject had been brought before them with great clearness. The matters mentioned required a considerable amount of study before they could be adequately discussed, but he ventured to prophesy that those volume changes would in time to come take an equally important position with that occupied by the work on silicon.

MR. SMITH (Chesterfield) said that while he had listened to the paper with great pleasure he would like to know the meaning of the term "washed iron." As to silicon, Mr. Stead, some years ago, said the true influence of silicon was discovered by Ledebur, but it was not put to any practical use until Mr. Wood and Mr. Stead put their heads together. Years ago there were in the Middlesborough district many tons of silicon iron, commonly known as "burnt iron," and they did not know what to do with it, except to put it in the furnace and melt it up; but as soon as it was found that by mixing a percentage of mottled iron a fairly good foundry iron could be produced, there was an actual demand for the metal.

PROFESSOR TURNER, replying, said he was much obliged to the critics for the kind remarks made. He believed it was quite true that Mr. Charles Wood was the first to make castings from siliceous iron. They used the term castings there in the sense of articles ready for sale. His own paper, giving particulars of the influence of silicon in cast iron, was read before the Chemical Society in June, 1885. At that time Mr. Charles Wood and Mr. Stead were experimenting with that kind of iron with the object of using it up if possible. Mr. Wood was personally known to him and they were very friendly. Mr. Wood saw a summary of his (Professor Turner's) paper, and immediately said, "There is a point at which we should aim, and at that percentage you will get good results." In a Glasgow paper, in the autumn of that year, Mr. Stead and Mr. Wood commenced their paper by referring to his results. He was quite willing to agree that many people had tried to get what they now knew as fine-grain graphite, but they did not know what they were aiming at. They knew there was a particular structure of iron which they judged by physical tests, but which was now known to correspond with fine-grained graphite. In reference to the forms in which silicon occurred, there were at least three different silicides, with varying

proportions of iron and silicon. For all ordinary cases they had to deal with, he thought Fe_2Si, giving a eutectic with about 18 or 19 per cent. of metallic iron just where it began to be resistant to acids was the most fusible and the most readily melted of the whole series, and with about 18 to 20 per cent. of silicon. Below that they always dealt with that silicide in solution. He had given a good deal of attention to the cause of glazed pig-iron, and in his first paper, in 1885, he put side by side certain irons which were glazed and others which were not, the reason for which he judged to be something beyond silicon, which he could not then explain. Since then a number of analyses had been taken. Mr. Hudson had carried on an investigation and they had got glazed iron, particularly from Northampton, and found that it contained high sulphur, as well as high silicon, for example, 4¼ per cent. silicon and 0.8 of sulphur. If it contained over 1 per cent. of sulphur it would be glazed or burnt, whatever it might be called.

Mr. Pilkington remarked that there were two forms of glazed pig-iron, foundry glazed and forge glazed. In South Staffordshire they used a sulphur pig, but that was not forge glazed.

Professor Turner, continuing, said that if they asked him what was the cause of silky pig he would ask to see a piece, because there were so many descriptions, and anything that was glazy in appearance was called glazed, but they were not necessarily of the same kind, although they were classified together. The ordinary glazed appearance was connected with just a little higher sulphur. With regard to white irons with 1 per cent. of sulphur, he had rather a low carbon and small bars containing 1 per cent., but if the bars were larger they could get a glaze with ½ per cent. of silicon. With regard to Mr. Hatfield's bars, those experiments were no doubt done with every reasonable care. He had considered them carefully, and his own explanation of the irregular results was that Mr. Hatfield had not the advantage of consulting a skilled engineer before selecting the form of his test pieces. He (Professor Turner) went to Sir Alexander B. W. Kennedy and enquired as to the best form of test pieces. He followed the advice given for tensile testing, and he had since considered it extremely fortunate that he had that advice. Mr. Hatfield had small short bars, which were the worst possible form for the purpose, and he had the greatest difficulty in getting a straight pull on his bars. A better form would have given better results.

It had been said that volume changes would be of great importance in dealing with cast iron and other metals. A paper was to be published at the next meeting of the Institute of Metals on "Volume Changes in Brass," and experiments had been made by one of his students named Murray. He believed Mr. Murray's results would prove almost epoch-making, in reference to the question of brass. With regard to Mr. Smith's enquiry as to "washed iron," it was a commercial product which could be bought under that name, and which was chemically as nearly as possible pure cast iron, with 3 per cent. of carbon in the combined form and nothing else. It was obtained by melting a fairly good quality of hematite pig-iron in a basic-lined furnace.

The President then called upon Mr. W. H. Sherburn (of Warrington), who addressed the meeting to the following effect:—

THE PRODUCTION OF PATTERNS FOR LIGHT CASTINGS.

I wish to say something on this question from the designer's point of view. I think it is very appropriate that the subject should be brought before such a meeting as this from that point of view, because it gives the technical man a good opportunity of helping the designer in the right direction. The general term "light castings," covers a very wide range. I will, therefore, direct your attention to only one metal and one branch, which I will call the domestic branch—that which deals mostly with the fireplace and its furnishings. A pattern of some sort is a necessity before castings can be produced, but the pattern department is often a very unappreciated necessity in a works. I won't say it is a necessary evil, though the expense of it is looked upon in that way by many persons. The range of patterns, although we have circumscribed our consideration, is still wide, ranging as it does from the simplest flat plate, which a boy can make, to the most elaborately modelled design from a high-class artist. Just as the artistic finish of the pattern has so wide a range, so do materials and methods by which they are produced differ. Wood, of course, for all the plainer patterns, is generally the material used, but in the patterns which we are particularly considering wood takes a secondary position, except as a backing for the patterns made in other materials.

First of all we have clay, plaster of Paris, wax and soft metal of various descriptions. Literature on the subject of light pattern-making is at present very sparse. A few years ago, there was very little literature on pattern-making at all, but of late years there have been quite a number of manuals on pattern-making brought out, some of them very good, but almost all dealing with engineering and its allied branches. There is still great need of a manual on the construction of light patterns, and on the effect of shrinkage, form and thickness, etc., on light castings. This manual has been long overdue.

The practice of the old masters where the apprentice and the journeyman worked with the master (usually a clever craftsman), is still the best way, if it can be accomplished. From its results it has up to the present produced the highest work from the artistic point of view. The old craftsmen were very comprehensive. I have one in my mind just now, Benvenuto Cellini. I should advise foundrymen to study the life of a man like Cellini, simply as a relaxation from the hum-drum of technical work, because I never came across so much human nature mixed up with practical work as appears in his autobiography. It will appeal very strongly to many foundrymen, and especially to moulders. After spending perhaps years in getting a model with the highest artistic results, he began to be his own moulder, and not only that, but also the constructor of his own furnace. He also mixed his own metals and melted them. The way he began to model is a revelation. He modelled his core first in a mixture which afterwards had to be knocked out. On that core—and this shows the amount of artistic knowledge necessary, and the genius there must have been in the man—he modelled in wax his finished model, say a figure such as his Perseus. Over that he laid his sand again and finished the large mould ready for casting. During these processes, he was making preparation for running away the wax from between the core and the outer mould. After melting out the wax, this occupying perhaps some days, the vacant space was prepared for the metal. Just imagine what must have been his feelings! Two years' of work would be wasted if that casting proved a waster. He goes on to tell us how he prepared his furnace, charged it with the metal, worked until he could work no longer, and went to bed in a fever. After he had been resting awhile, some of his workmen came to him in great fear. There was something going wrong with the furnace. He went to see what was the matter and found that while he had left his metal melting all right, it had begun to solidify again in the furnace. He began kicking about the boys and the men and women there, and set to work again

himself. He got a load of oak chips to make the fire hotter. He then fetched out his pewter vessels and threw them into the furnace, and after a while the metal was molten again. He succeeded in getting a casting which proved a sound one.

There was a great deal of human nature in Benvenuto Cellini. I draw your attention to this, because I think we foundrymen are apt to get a little too prosy. We get so technical that we are in danger of forgetting some other sides of our nature. All the sides of this man went into his work. But the old days and the old ways have passed away. Modern methods now prevail, and there are weaknesses which come from specialising our work too much. The designer, pattern-maker, and moulder are now very distinct persons, each with a distinct and marked knowledge; and unfortunately the knowledge of one does not run far enough into the knowledge of the other, with the result of misunderstanding and weakness which it is our duty to find out and to remedy.

First of all, there must be co-operation in work, and not only co-operation, but sympathy between the designer, the pattern-maker and the moulder. The moulder must know all that there is to be known about moulding, so far as his department is concerned. He must also know a little about pattern-

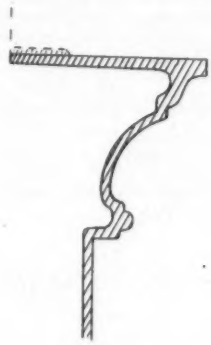


FIG. 1.—SECTION OF FRIEZE: SHOWING INEQUALITIES AND DIFFICULTIES.

making and then he will not so readily abuse the pattern-maker, and the pattern-maker will not need to retaliate. The pattern-maker must know all there is to be known about pattern-making; he must also know something about moulding, and the action of the metal in cooling. He should also know something about design and about ornament. I am giving the pattern-maker a pretty high mark to aim at, but he should attempt it, and I am speaking thus from experience. Then the designer must know most of all. First, he must keep in view the essential purpose of the pattern he is designing. Then he must know the best form in which it can be put without destroying in any way its use. Beauty and usefulness must be combined. Therefore, he must know all about designing, and as far as he may a great deal about pattern-making, and something about moulding. He must have the most comprehensive knowledge of all. Unfortunately, this has frequently not obtained in the light castings trade. Very often the designs have been bought from an artist who has known practically nothing of the technicality of cast iron. He has known his art; he has perhaps known all about architectural shapes and forms, and he has given correct designs from the design point of view. But unfortunately he has been without that most essential knowledge of the forms which are suitable for the metal in which his design is to be produced, and how he can best add to the beauty of his forms without weakening the essentials. Of course, the designer is usually a very sensitive person. Naturally so, and he does not like the pattern-maker to take liberties with his forms and shapes. Unfortunately, he frequently does things in his artistic capacity which must be marred before they can be put into castings. Now. with this knowledge that I am pleading for (knowledge which he ought to have), he would be saved from those annoyances. Let us take an example. He will design, say, a freize of the description shown in Fig. 1; a freize on a mantelpiece, or some part of a grate. Those who have had any experience in castings know what a difficult section that is to cast straight, but the designer without this technical knowledge may give right-angled edges, and deep sections. Now it is well known in the foundry that unless modified by the pattern-maker, when that design comes into the moulding shop there will be trouble. The outer edge will cool very rapidly. The deep part will keep heated, a strain will be the result. Trouble will again occur with right-angled edges; therefore all

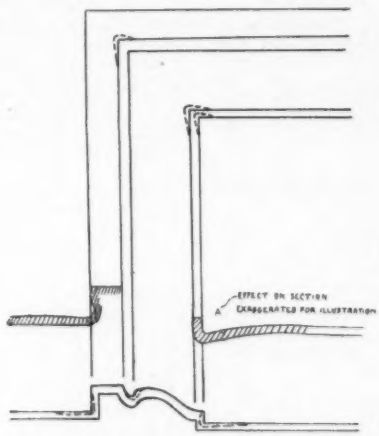


FIG. 2.—CORNER OF PANEL MOULDING: SHOWING EFFECT OF REPEATED CASTING.

these points must be provided for. Now, if the designer had had the amount of metallurgical knowledge necessary to keep from those troubles, he would have designed a different section without taking away from the beauty of his conception at all.

Then again, in constructing a panel, he will perhaps give you a section something like that shown in Fig. 2. Of course, it must be remembered that such a pattern will have to be cast three times down; the original pattern, a working pattern or plate, and the casting. Plate moulding will exaggerate all the troubles which the ordinary moulding involves in respect to bends, twists or shrinkages. Taking a panel with right angles, two things will occur to mar the shape of it. It is well known that a square mitre or right-angle in cast iron is a point of weakness. It begins to lose shape and substance at all these mitres in the direction shown, until, when the casting is got from the plate, the mitres sink and lose shape. This tendency could have been provided against as well as another tendency which the plain part of the panel will show, to sink near the moulding in a cushion form. Those are the little things that a designer should know. Having had experience he would probably have filled the inner angles of his

panel without losing anything in effect. In fact, it is a tendency of modern forms in design to be softened in that way. There would then be allowed for that natural tendency of iron in cooling and by that means a more presentable article and also a stronger one would be obtained.

Another difficult problem arises with the usual mantelshelf edge. A frequent form of mantelshelf edge would be something like that in Fig. 4. To make that in one piece would involve a heavy edge (A) on a light plate, and it is easy to guess what would then transpire. There is another method of constructing it which gives two castings instead of one; that would be to make the top plate form part of the edge and the bottom plate the other part (B). Difficulties will occur in making these points accommodate each other. But if the designer knows the action of the iron in shrinking, he will be able to meet all these cases and will get not only an artistic but also a technically good production from the material he uses.

If the pattern is to be a very ornamental one, the designer will make his model in clay. From that he will cast a mould in plaster and usually he will

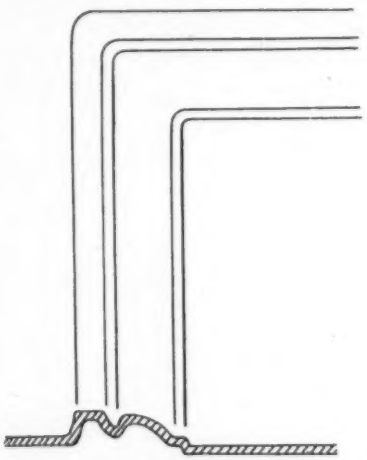


FIG. 3.—CORNER OF PANEL AND SECTIONS: SUGGESTED REMEDY.

overlay that plaster mould with a thickness of clay equal to the thickness that is wanted in the finished casting. The back mould is then cast in plaster, and, when set, the moulds are separated and the clay removed, the space being filled with wax. He now has the wax cast from which he can take a casting in soft metal, lead and tin or similar metal. It is then cleaned or chased (to use another term for it). In older times, the modeller would frequently model the plain mouldings. I quite well remember many designs sent in completely modelled in this way. I have known the artist object to such a mechanical thing as a run-up moulding. I think we have, however, now got beyond that state of things. Mouldings are now usually run up in plaster. Those who have seen the August number of the FOUNDRY TRADE JOURNAL may have noticed an article there on gutters, which illustrates a method of running up in plaster with two templates of zinc and copper. A pair of templates are made corresponding with the two surfaces of the required moulding—these are fixed to a wood frame, and block run up in plaster of Paris. When this has set it is varnished and oiled, the inner template is taken off the frame, leaving a space which is filled in with a thick creamy mixture of plaster of Paris, which sets rapidly while the worker is running over it again with the single template. When this second plaster is set, which represents the moulding required, it is removed and varnished ready for casting from.

Methods differ greatly in different districts, but we are gradually getting more cosmopolitan. There used to be a Scottish method and an English method of pattern-making, each of them, of course, being the best. (Laughter.) The English method was what I may call "the more artistic method." The Scottish we may call "the scientific." The Scottish pattern-maker always paid very great attention to the rightness of his lines, and the evenness of his thicknesses, and all that sort of thing. The English pattern-maker did nothing of the sort, but he looked more to the artistic and he was very proud of his work from an artistic point of view when he had done it. You will see at once, I think, that both these methods were right to a certain extent, and rejoice with me that during the last few years there had been a blending of these two to the advantage of both. At first, of course, there was as much disagreement as when oil and vinegar come together (I won't say which was which), but each one of them came at last to see the wisdom of co-operation, and all the best pattern-making I think is now done on

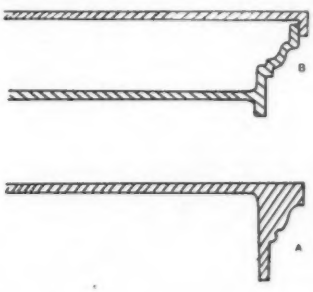


FIG. 4.—MANTLE SHELVES: (A) BAD AND (B) GOOD FORM.

that co-operative basis. The Englishman learned from the Scotchman the advantage and the use of his geometric way, and the Scotchman on his part saw where he was lacking and had made great efforts to overcome it. So that really we now have a "British" system of pattern-making rather than two national ones. (Applause.)

Having got into our system of pattern-making which combines both the artistic and the technical we have to grapple with the difficulties on scientific lines and from the designer's point of view. I believe that, generally speaking, light castings will show in an exaggerated form all the difficulties that you have been dealing with in the larger castings, such as engineering castings. Therefore, it is all the more interesting to study the subject from the light castings point of view.

The modern method of plate moulding has emphasised these difficulties. Difficult points which occur in an ordinary casting come in with much more emphasis and much more mischief with an article which is cast on the plate. An edge, say, which is losing weight all the time, will tend very much to lose more in proportion after it is put on the plate. There are the points that are worthy

of consideration. They are problems just ripe for treatment, and they are problems that have not been dealt with very largely. Our President has touched upon them this morning, and so has Professor Turner, and we may all agree, I think, with Professor Turner in saying that so far from having solved all the problems of cast iron we have but just got to the interesting part of our work. We are beginning to work on definite lines, and as the artist learns more about the technical side and the technical workers see more what the artist has in view, our work will proceed very much better.

Discussion.

The PRESIDENT, in opening the discussion, said that they would all agree with Mr. Sherburn that close touch between the designer and the patternmaker and the foundry was essential. He himself did not think that the necessity was so marked in the light pattern trade as in the engineering branches, but no doubt, in all cases, the three departments must work hand in hand if the best results were to be obtained.

MR. W. E. NOON asked if in running up plaster patterns Mr. Sherburn used any other material?

MR. SHERBURN: Usually it is not necessary, but if the plaster of Paris appears to be going to set too rapidly a little lime may be put in.

The PRESIDENT: The questioner wanted to know, I think, if with plaster moulds you put in any backing. I have in engineering work put in sieved iron to give it strength; that is, where it was to be used as a permanent pattern.

MR. SHERBURN: The more important point is the way the plaster is mixed. You want to get it the right consistency, say, that of batter, but you do not want to be mixing it too long. There is a point at which it will not set. The more it is disturbed the more mischief you do. It will never set if you keep disturbing it too long.

MR. HEGGIE said that Mr. Sherburn had made everything very clear, but he should like to point out that it put the patternmaker in a very difficult position if he had to make up for what the designer did not know, and what the moulder did not know. (Laughter, and applause.) He had hoped Mr. Sherburn would have gone on to describe the trouble they had in relation to twisting and bending of patterns, particularly iron patterns and the castings from these patterns. A lead composition is made first, and the casting pattern obtained from that. The result is that in some cases an allowance of anything from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. has to be made to get a proper casting. If it has to be dealt with three times, it makes a big difference. Sometimes a certain amount of camber is given by altering the runners.

The PRESIDENT thanked the readers of papers that morning and said that they had provided the members with a great deal of matter for thought. Perhaps Mr. Sherburn would insert in his paper something with regard to the twisting and bending.

MR. SHERBURN said that the points raised by Mr. Heggie were very important. It had always been a moot point among patternmakers as to which was the right thing to do in order to bend the pattern to counteract its natural tendency—whether to put weight on or to take weight off, to bring it right. For instance, in one of the examples he had shown them the tendency would be for the pattern to go hollow. The usual way to counteract that was by what they called sweeping it, putting on a backing of boards to counteract the shrinkage which might be taking place. With regard to twists and bends they might be sure of this, that iron followed no erratic law; it followed a natural law, and there was a reason for all the twists and bends which occurred. In a panel, for instance, difficulty was frequently experienced in proportioning the thickness of the centre of the panel and the outside in relation to the position in which they were going to put the runners. Of course, if they were going to put that flat to suit particular conditions, instead of as was usually done, running it up on the edge, then it would be run up with flat gates from the centre.

The Convention then adjourned.

SECOND DAY'S MEETING.

The business of the Convention was resumed on the Wednesday morning in the Medical Theatre of the Birmingham University, the President (Mr. F. J. Cook), in the chair.

The first paper was by Mr. A. H. Hiorns, Principal of the Metallurgical Section, Birmingham Technical School, and entitled "Influence of Chemical Compounds on the Properties of Cast Iron."

THE INFLUENCE OF CHEMICAL COMPOUNDS ON THE PROPERTIES OF CAST IRON.

BY A. H. HIORNS.

Much work has been done of late years in determining the influence of certain elements on the properties of cast-iron, and several workers have studied the formation of chemical compounds of iron with those elements which are usually associated with iron in its commercial varieties. As a result the existence of several well-defined compounds having definite physical properties has been established. It is now well recognised that compounds are formed in alloys at definite temperatures. The result is that on cooling such an alloy the compound is decomposed into its constituents. In other cases the reverse condition occurs. It naturally follows that the properties of such an alloy must vary with the conditions of such elements, according as they exist in chemical combination or in the free state. Very closely associated with the subject of chemical combination is that of solution, both liquid and solid. A chemical compound in a metal is generally a hard and brittle substance; it is therefore reasonable to assume that it tends to impart those properties to the metal in which it is involved, in proportion to the quantity present, but the manner in which the compound exists in the alloy, whether segregated in the free state, in solution, or in a finely-divided state as in eutectic mixtures, modifies its influence on the whole mass. As an illustration may be taken the case of the carbide of iron, Fe_3C. This carbide exists in iron in three forms, viz., in solid solution known as martensite, in segregated patches known as cementite, and in fine striations as pearlite. In solid solution as in hardened steel and white cast-iron it exerts the maximum hardening effect, and in fine striations the minimum hardening effect. Also the maximum hardness is associated with the maximum brittleness. The chemical compounds of one metal with another do not in general follow the law of valency, so that they are of the type known as molecular; but the above law is obeyed in the compounds of

non-metals with iron. It may also be stated that when the law of valency is strictly followed, the combinations are of a stable character, and when it is not followed the compounds are easily decomposed, and the properties of the alloys will vary with the strength of the chemical combinations present. Also in the case of weak combinations the properties will vary much less from the properties of the components than in the case of strong combinations. The usual combinations of elements with iron in cast iron and steel are of the strong character, hence they are capable of profoundly modifying their properties.

The solid solutions of elements in compounds of iron, while fairly strong, are much less so than the chemical compounds, and the properties of such solutions do not differ very markedly from the mean of the properties of the bodies dissolved in each other. In a solution the components are completely merged, but in indefinite and varying proportions, so that the components cannot be distinguished by the microscope or any other means. Seeing that a solid solution may contain varying quantities, it may often happen that the quantities present may be in atomic proportions, yet this will not prove it to be a chemical compound.

There is another state in which elements may exist in iron, analogous to a solid solution. The two elements are isomorphous; they crystallise in the same shape. Proportions of each may form one homogeneous crystal, the molecules of each substance completely identifying themselves with the molecules of the other. Such isomorphous crystals are also called "mixed crystals." As an illustration we may take iron and manganese. The molecules of each unite to form one homogeneous crystal. These elements therefore constitute a solid solution, but two elements of different crystalline forms may merge and form a homogeneous solid, and while this would be a solid solution, it would not be a true isomorphous mixture. Solid solution may consist of a chemical compound dissolved in a metal, as in the case of the carbide of iron, Fe_3C, dissolved in iron, which is the condition in white cast-iron and hardened steel. It may be granted that an isomorphous mixture of a solid solution has properties differing from the properties of the components in proportion to the relative quantities present, so that the existence of manganese or Fe_3C in iron will modify the properties of iron in proportion to their amounts. Further, a dissolved body may only be capable of existing in solid solution under certain conditions of temperature, etc. For example, if the solution of Fe_3C in iron is cooled down below 1,000 degrees C. it will more or less fall completely out of solution, if sufficient time be allowed for the separation. It may also be granted that a solvent generally is capable of taking up a limited quantity of another body, and if an excess be added beyond the saturation point, such excess will not be dissolved, or if dissolved, will readily separate out again.

It is proposed by the author to consider only the usual elements found in cast-iron. These are carbon, silicon, phosphorus, sulphur, and manganese, of which carbon, silicon, phosphorus, and sulphur form chemical compounds with iron, but not manganese. The latter, however, forms compounds with carbon, sulphur, silicon, and phosphorus. Silicon forms compounds with sulphur, but not with carbon, at the temperature at which cast-iron is produced. Sulphur unites with carbon to form a volatile compound.

As therefore several compounds can be formed in cast-iron it is reasonable to suppose that they play an important part in controlling the properties of the various grades of cast-iron, and in the case of carbon the most important of all influences in determining those properties. If, therefore, it is desired to arrive at a correct idea of the nature and properties of commercial cast-iron, a close study of the chemical compounds present must be pursued.

Influence of Chemical Compounds on Soundness of Castings.

That the casting temperature has an influence on the formation of blowholes is generally recognised, but this is not the only, nor in many cases the chief cause. During the casting operation gases are absorbed. A partial decomposition of the moisture of the atmosphere always occurs, and the dissociated hydrogen combines with the flowing metal. Often carbonic oxide is formed by the union of the carbon of the mould with the oxygen of any oxide in the metal, but this is only partially absorbed, most of it escaping as gas, and the rest is trapped in the metal as blowholes. Iron does not form any strong combination with gases, which are dissociated as soon as the temperature falls sufficiently to permit of their evolution. As long as the surface of the metal is liquid the gases will freely escape, but as soon as the crust of the metal is sufficiently thick to resist the pressure of the ascending gases they will be retained in the metal; but the whole process of evolution depends on the space available for the gases within the metal.

The three elements which have a most important influence in preventing or modifying the blowholes are silicon, manganese, and aluminium, all of which tend to increase the capacity of iron for excluding gases. Now, as aluminium is not usually employed in cast-iron, it is only necessary to consider the two others, although they are inferior to aluminium in the prevention of blowholes. The more the metal cools the stronger is the tendency of gases to escape, but this tendency may be counteracted by the presence of silicon, or manganese. Conversely, in the absence of silicon or manganese, the gases begin to escape at a higher temperature and are evolved during the cooling so that blowholes result. When the whole of the metal is solid, the gases can no longer form, and are therefore kept in solution. The higher the percentage of silicon and manganeses the greater will be the tendency to keep the gases in solution till a temperature is reached when the whole metal is solid. If the metal is cast at an abnormally high temperature, it will afford facilities for the evolution of gases and the formation of blowholes, since the interior will remain liquid a long time after the surface has solidified. The effect of sulphur and phosphorus is to lower the freezing point of the iron and keep the interior metal longer in the liquid state, thus causing facilities for formation of gases, and therefore formation of blowholes. Silicon, however, causes iron to pass very rapidly from the liquid to the solid condition, and thus in a great measure prevents the evolution of occluded gases.

Brinell found that for steel, under conditions that are normal at Fagersta, Sweden, if the sum of the percentage of manganese plus 5.2 times the percentage of silicon is as great as 2.05 then the steel is free from blowholes. If the sum is reduced to 0.28 the blowholes are deep seated. If the sum is 1.66 there is just a small quantity of hardly visible blowholes. If between these extremes, the blowholes are near the surface. These numbers must be varied with the casting temperature and size of the casting, being less for a small casting. He also found that the effect of 0.0184 per cent. of

aluminium was equivalent to the above sum of 1.66. It may be added that a too high or a too low casting temperature causes the formation of many blowholes. It is thought that the reason why excessively high temperature causes external blowholes is, that it causes the carbon of the molten metal to react on the oxide of iron on the surface of the casting with the formation of carbonic oxide gas.

Both grey and white cast-iron evolve gas copiously on setting, but the white iron is more liable to blowholes than the grey iron. This is partly due to the fact that white iron passes through a pasty stage in solidifying, while grey iron passes quickly from the liquid to the solid state. Three sources of gas bubbles have been suggested (1) the mechanical retention of air drawn into the metal while pouring; (2) the formation of carbonic oxide gas by chemical reaction; and (3) the gassification of substances which have existed in a non-gaseous state (solution, chemical union), and which had earlier been formed by reaction or acquired from the atmosphere or furnace gases. Blowholes are probably due chiefly to hydrogen, nitrogen, and carbonic oxide. The last may be formed by superficial action of the carbon on the oxygen of the air, as it is much larger in the early than in the later escaping mould gases.

The presence of manganese and silicon in the iron has been stated to greatly assist in the prevention of blowholes. They appear to increase the solvent power of iron for gases, but they may also prevent the formation of carbonic oxide by being preferentially oxidised. In their absence the solvent power of iron diminishes, and a greater number of blowholes results. The shape of blowholes is more regular when deep seated than when near the surface of a casting. Martens found with the microscope three sets of markings and intrusions in blowholes :—(1) Stripes, furrows on foldings, caused by compression due to contraction of the neighbouring metal; (2) intrusions caused by the entrance of gas from the surrounding metal after the walls of the surrounding blowholes had become pasty; (3) intrusions of metal due to change of volume in the surrounding metal by solidification of different components of the mass at different periods. During solidification the conditions which determine whether gas shall escape or not depend on the solvent power of the metal and on the existing pressure.

Influence of Chemical Compounds on Chill.

In the first place it may be stated that chilled iron is white iron, and therefore depends on the amount of combined carbon present, this being influenced by the temperature of casting. If an increase of combined carbon does not give a greater depth of true chill, the iron at the back of the chill contains more combined carbon, so that the influence of combined carbon is imparted to a considerable amount of the iron.

Silicon when present in iron forms a chemical compound, which, according to Carnot and Goutal, has a formula Fe_2Si, and this in cast-irons is dissolved in the iron, forming a solid solution, which is harder and more brittle than the iron alone. Now as this silicon is locked up in the iron, its influence on the condition of the carbon, whether combined or uncombined, is very limited. The author took a sample of cast-iron containing 1 per cent. silicon and free from further elements other than iron and carbon, and quenched it in water from 1,100 degrees C. Practically the whole of the combined carbon remained in the combined form. It is now generally recognised that carbon which is in solution in molten iron remains in that state if it is rapidly cooled. Adamson mentioned a sample of silicon steel with 0.8 per cent. combined carbon and no graphite. Silicide of iron also lowers the saturation point of iron and carbon, but it by no means follows that cast-irons with high silicon are the lowest in carbon or contain the least amount of combined carbon. In fact, the separation of carbon from iron is chiefly a function of time and temperature.

Phosphorus is present in cast-iron as a phosphide, probably Fe_3P, which is readily fusible, fairly hard, and brittle. Unlike the silicide phosphide of iron is not dissolved in the crystals of iron, but exists in the portion which solidifies last, and therefore is a constituent of the eutectic mixture. It therefore does not exert any great influence on the carbon, either to keep it in the combined form or to cause it to separate out as graphite. One effect of the phosphide is to lower the percentage of total carbon. Phosphorus, in consequence of its influence in reducing the total carbon and lowering the freezing point of iron, is inimical in iron for chilling, since it reduces the depth of true chill. Moreover, phosphide of iron, being a brittle body, tends to impart that property to the iron.

Sulphur with iron forms sulphide of iron which is a brittle substance, and while it tends to keep the carbon in the combined form and thus to promote chilling, it also tends to promote brittleness. Sulphide of iron is a comparatively fusible body and lowers the freezing point of iron, which therefore is opposed to chilling. For these reasons the amount of both phosphorus and sulphur should be low in iron for chill castings, which, while they must be hard, should at the same time not be brittle.

Manganese in moderate quantity is an advantage for chilling, inasmuch as it promotes the retention of combined carbon. It forms with carbon a carbide of manganese, and consequently increases the depth of chill. Up to 1 per cent. it does not materially interfere with transverse and deflection tests. In the presence of sulphur manganese sulphide is formed which has no effect on combined carbon, so that in this case manganese carbide promotes brittleness. For a good chilling iron the combined carbon should be about 0.8 per cent., the graphite about 2.4 per cent., silicon and manganese about 1 per cent. each, phosphorus about 0.4 per cent., and sulphur about 0.04 per cent.

Influence of Chemical Compounds on Segregation.

Segregation is a term applied to the phenomena presented by the more fusible parts of alloys and impure metals which are the last to solidify, being driven into certain local centres by the part which freezes first. Segregations are generally found near the upper part of the centre of a casting, and are more pronounced in large masses. Cast-iron is a complex alloy compound of carbides, silicides, phosphides, and sulphides, etc., contained in metallic iron. These different compounds vary in their freezing points, some remaining liquid much longer than others, and all have a lower freezing point than the metallic iron. Consequently those having the lowest freezing points will tend to segregate from the iron and collect in the hottest part of the castings, which will naturally be near the centre, as this is the last portion to solidify. It is not the extreme top of the casting which contains the most of the segregated compounds, as this is not the last to solidify, other things being equal. The more rapidly the cooling the less will be the segregation, and as the rapidity of cooling depends

largely upon the size of the casting, it follows that small castings are little liable to segregation. The proportions in which the segregating bodies are present will largely influence the result. The higher the proportion of impurities in the casting the greater will be the amount of segregation.

Mr. Stead has pointed out that segregation is closely connected with the size of the primary crystals of iron which solidify first, leaving a liquid mass which contained the greater part of the impurities. Quick cooling, or agitation of the mass on slow cooling, produces small primary crystals, and in iron the crystals are of the cubic system. When the crystals form rapidly they are so close together that very little of the segregate becomes entangled. Iron crystallises in "fir-tree" systems, which send out branches at right angles, and each of these send out branches at right angles to themselves and parallel to the primary system. The liquid portion of the metal becomes entangled in these branches. When the crystallisation is rapid the small crystals are so crowded together that there is no room for the branches to form and extend, so that very little of the segregate is entangled. This is the condition of the top portion of a casting. The next set of crystals to form from the still liquid and hotter portion are larger because of the longer time they have to grow. These can throw out branches in all directions like the boughs of a tree in a thick jungle, and therefore entangle a lot of the more fusible and segregated mass. The primary crystals are not pure iron, but iron saturated probably with dissolved carbide. The bodies in cast-iron most likely to segregate are the carbides, phosphides, and sulphides of iron, being more fusible and of lower density than the alloys of iron and manganese. The segregation of manganese carbide and sulphide is favoured when the percentage of manganese present is in large excess of the percentage of phosphorus and sulphur. It is often found that the segregation of one impurity favours the segregation of others. When there is an appreciable segregation of manganese, sulphur is generally present, and the segregate is therefore sulphide of manganese. The presence of the metals chromium and tungsten favours segregation, whilst the presence of nickel tends to prevent it and to make the casting more uniform.

Influence of Chemical Compounds on Shrinkage.

The contraction of cast-iron on cooling varies with the proportions of the castings and the nature of the iron employed. When the constituents and the rate of cooling are such as to favour the production of combined carbon the shrinkage is greater than when the opposite condition prevails. Therefore, white iron contracts more than grey iron on cooling. The formation of a chemical compound is often accompanied by contraction, and a chemical compound in solution in a metal generally has the effect of closing up the grain when the compound does not exceed a certain amount, as for example, phosphorus in copper. Therefore, the presence of carbide of iron (Fe_3C) in solution in iron causes contraction of the whole mass, hence the greater shrinkage of white iron.

Manganese has also the power of uniting with carbon to form a carbide of manganese which dissolves in iron, and which possesses the same general tendency as carbide of iron to close up the grain and therefore cause contraction. But if sulphur is present the manganese may unite with it to form sulphide of manganese, which segregates in different parts of the casting. In this case the manganese, although in chemical combination, has no influence on the condition of the carbon, so that the carbon might exist in the free form as graphite, in which case the contraction is due to the iron and elements other than manganese and sulphur. While manganese carbide produces white iron with much consequent shrinkage, manganese may, as stated above, be present in quantity and produce neither chilling nor shrinkage, the iron behaving as though it were absent.

Phosphorus is said to lessen the shrinkage of cast-iron, but it is difficult to see how this can be the case since phosphide of iron, in the proportions usually present in cast-iron, is positively stated by Stead to have no influence on the carbon, neither in causing combined carbon to be retained nor graphite to be set free. If then the condition of the carbon in iron is the determining factor as regards shrinkage, it is evident that phosphorus can have no influence on the shrinkage. But phosphide of iron is in solution in iron at high temperatures, and if the iron is rapidly cooled it remains in solution. If, therefore, the effect of a chemical compound in solution is to close up the grain and cause contraction, phosphorus in that case promotes shrinkage. But ordinarily the phosphide of iron is thrown out of solution and exists as a free phosphide. In that case it probably has no influence on the contraction, except mechanically in enlarging the eutectic mixture, and thus tending to neutralise the contracting effects of the carbide.

The effect of sulphur on cast-iron depends to a great extent on the presence or absence of manganese. In the absence of manganese it unites with iron to form sulphide of iron, which is uniformly distributed through the mass when the amount of sulphur is under 0.08 per cent According to Levy the first freezing point of iron containing 1 per cent. sulphur is 1,187 degrees C., and with 4.3 per cent. carbon the eutectic mixture freezes at 1,118 degrees C., due to the iron sulphide forming a constituent of the eutectic. The iron sulphide seems to cement the otherwise discontinuous pearlite. With low sulphur, which is the case in all iron castings, the pearlite and sulphide tend to coalesce with rounded mass. By the interposing of sulphide the pearlite is prevented from massing together, which is considered by Levy to be a preliminary to its decomposition into iron and graphite. He also suggests that the pressure of the iron sulphide prevents the expansion which accompanies the formation of iron and graphite from the decomposition of cementite. If, therefore, sulphide of iron is able to mechanically prevent the formation of graphite the iron must be white, because the carbide is kept in solution in the iron, and as combined carbon increases the shrinkage. Sulphur in iron in the absence of manganese promotes contraction during cooling.

Discussion.

The PRESIDENT said that they had had a technical paper, but the technical matters had been put to them in a very simple way only possible to one who was thoroughly familiar with his subject. No doubt it would lead to a very interesting discussion.

PROFESSOR TURNER, in opening the discussion, said that he should like first of all to say how fortunate they were in Birmingham in having two institutions, both of which dealt with metallurgical subjects. While the University had to deal almost entirely with day classes, they had the Technical School, dealing almost entirely with evening students, with a very strong Metallurgical Department, at the head of which Mr. Hiorns had been working now for

a number of years. He (the speaker) was much obliged to Mr. Hiorns for the few remarks made at the end of the paper, because these referred to something of which he ought to have made some mention in his paper, namely, the work done by Mr. Levy on cast-iron. Mr. Levy, who was a member of his (Professor Turner's) staff, had recently published a paper on the interesting question as to why sulphur in cast iron prevents the formation of graphite and causes the carbon to remain in a combined form. To some extent, Mr. Levy's suggestions remained in the position of theory, though there was much microscopic evidence in support of his theory. Mr. Levy's theory was that the pearlite must aggregate together before it can decompose to form graphite, and that the particles are prevented from coalescing by the presence of the sulphide of iron. The little particles wanted, so to speak, to get together to form big lumps. If this were continued till the lumps got sufficiently large, the next stage of decomposition could be carried on, but the sulphide of iron, being a plastic body, acted as a lubricant and prevented these little particles getting together; and so the iron was retained in solution. Mr. Hiorns had made some statements which were perfectly correct so long as they were understood to be limited. No doubt Mr. Hiorns recognised that. His statements were perfectly true, within ordinary foundry limits. Suppose they took 3½ per cent. silicon foundry iron, it did not necessarily follow that the carbon was low. It might be fairly high or a little lower than usual. If they got high proportions of silicon, that was to say high from the chemical point of view, not from the founder's point of view, say 10 to 15 or 50 per cent., then there was no doubt that the silicon did lower the carbon. The same was true of the phosphorus referred to by Mr. Hiorns in the next paragraph of his paper, where he said, "One effect of the phosphorus is to lower the percentage of the total carbon. Phosphorus in consequence of its influence in reducing the total carbon and lowering the freezing point of iron is inimical in iron for chilling, since it reduces the depth of true chill. Moreover, phosphide of iron, being a brittle body, tends to impart that property to the iron." As long as they had only ¾ to 1 per cent. of phosphorus they did not notice any reduction in the amount of the carbon, but when the phosphorus got higher the carbon was reduced. They had had experience of this at the University during the past session in some experiments which they had conducted in the laboratory. They had been endeavouring to prepare silicide, iron rich in silicon and iron rich in phosphorus, the object being to use them as the one end of a series. At the other end of the series they were going to use ordinary cast iron. They wanted to make one end cast iron, with 3½ per cent. carbon, and the other end one rich in silicon. But in adding the 3½ per cent. of carbon to pig-iron they found that the carbon gave it different peculiarities. It was an extremely difficult matter to get the alloy which they had in view. The carbon separated in the form of kish, and could be scraped off the surface as powder. All the material would not mix, and they had had to resort to another method of diluting the iron first with steel or pure iron and then add the silicon and the phosphorus. That showed that one could have high silicon and high phosphorus, and that the phosphorus not only prevented the carbon going in, but actually drew it out. Phosphorus was said, as Mr. Hiorns told them, to lessen the shrinkage of cast iron, but, Mr. Hiorns added, "It is difficult to see how this can be the case, since phosphide of iron in the proportion usually present in cast iron is positively stated by Stead to have no influence on the carbon, neither in causing combined carbon to be retained, nor graphite to be set free. If, then, the condition of the carbon in iron is the determining factor as regards shrinkage, it is evident that phosphorus would have no effect on the shrinkage. But phosphide of iron is in solution in iron at a high temperature, and if the iron is rapidly cooled it remains in solution." Now, as long as the phosphide of iron remained in solution, it appeared to produce very little effect on the shrinkage. To that extent, he quite agreed with Mr. Hiorns. But when the phosphides separated in the form of phosphide eutectic, they got an expansion—a reduction of the shrinkage. As soon as the substances which had been in solution tended to separate—in mechanical separation, crystallisation, or anything of that sort, there was an increase of volume, and that, as far as his observations had gone, would be the universal rule. Therefore, when, for instance, the graphite had been in solution in the iron and tended to separate they had two substances instead of one, namely, iron and carbon, and there was an expansion. As soon as the phosphide separated there again they had two substances instead of one, and there was another expansion. The same thing was true of the brasses, and all the other alloys they had examined. As soon as the close union (compound or solution) separated, there was an expansion. Phosphorus did not produce any effect on the chill, but in grey iron, when the phosphorus separated, it did produce on effect on the chill.

Mr. Buchanan said that he was quite in accord with what had been said about the value of the paper. Mr. Hiorns had told them that a high casting temperature facilitated the evolution of gases and the formation of blowholes. He (Mr. Buchanan) thought that was contrary to the usual foundry experience. He thought they were pretty unanimously of the opinion that castings which were cast hot had a better chance of being solid (that was from the blowhole point of view) than those cast dull. (Hear, hear.) There might be something else in the foundryman's mind when he cast hot. He provided against segregation taking place too soon, or, rather, the extrusion say of kish, and that was the one thing that he feared. The foundryman cast hot while the carbon was still held in solution by the temperature of the metal being high. If he held the metal until it was dull then the kish might separate. He (Mr Buchanan) did not see why a high temperature of casting should cause blowholes any more than casting at a dull temperature. If sulphur were present in either the dull or the hot iron there was a danger it was agreed, of certain kinds of blowholes forming especially pinholes, which were caused by sulphur. When sulphur was present, it was a matter of indifference from that point of view whether the metal was dull or hot when cast, because the metal in both cases had to drop on its way to cooling to a certain temperature at which it could no longer hold the sulphur in solution. Pinholes were bound to come out when sulphur was present, and there was nothing gained by reducing the casting temperature. He thought the very mechanical effect of pouring at above the temperature at which those gases come out facilitated the prevention of blowholes, so that the metal in the mould might be quiescent when it cooled to that temperature. As to Brinell's experiment, while Brinell was a brilliant experimenter, it should be remembered, that, after all, steel and cast iron were almost as dissimilar as any two metals could be. The purity of the steel, and the marked impurity of the cast iron, made them quite distinct. Consequently, it was not always wise to trust comparisons between the two. There was a process used in casting steel ingots which they had seen at works they had visited, namely, throwing sand on the top of the casting, putting a plate on that and wedging

it down. That was using a mechanical force which caused the steel to retain the gases which it would give off if left freely open at the top. In the case of cast iron they practically did the same thing in another way. They put head boxes on their moulds to supply a liquid pressure principally to keep the gases in solution, though they did not at first recognise that that was so. He thought there was very little doubt that cast iron did keep the gases in solution very much more readily than steel did, and he was not aware that any foundryman ever blamed the iron for blowholes—that was, blowholes as they understood them. The foundryman never called pinholes blowholes. He recognised that the pinholing was largely a question of the metal, and one that he had no control over, but for a blowhole pure and simple the foundryman seldom, if ever, blamed, or entirely blamed the metal. By blowholes he meant a hole in the casting which they found when on rapping a hammer across they could hear it. All foundrymen knew the sound when they were seeking for it. The only other example of holing caused by the giving up of gases from the sulphur, he thought, was mainly to be found in open sand plates. There they might find numerous holes of the sort of pear-shape, which was caused by the giving out of gases. These were caused because there was no head pressure to keep the gases in solution. This sort of thing was very much more readily avoided in cast iron than in steel. In regard to phosphide of iron not helping to prevent shrinkage, he had no doubt whatever that it did. It was quite possible to cast castings of, say, ½ cwt. in a solid mass if phosphorus was present. About 2½ per cent. would give a casting practically without any shrinkage whatever. It would be quite impossible to get a casting without shrinkage if they attempted to cast with hematite only. The difference between hematite and cinder pig was the phosphorus which the latter contained, and he attributed the non-shrinkage to the presence of phosphorus. He once, in the presence of Mr. Stead, suggested the explanation that the second expansion which took place in the cooling of iron was due to the segregation of the phosphide. Mr. Stead corrected him by saying that the expansion was due to the solidification of the phosphide which, as Professor Turner had explained, gave the second expansion in phosphoric iron when setting.

Mr. Percy Longmuir said he had intended to refer to the relations of high casting temperature to blowholes, but Mr. Buchanan had covered that point fairly well. Mr. Hiorns had told them that iron did not form any strong combination with gases which were dissociated as soon as the temperature fell sufficiently to permit of their evolution. Almost any iron after solidification under normal conditions could be heated, and gases would be evolved. It might have been heated to some 800 or 900 degrees, and apparently have exhausted all the gases, but by continuing the heating 200 or 300 degrees higher, further evolutions of gas would occur. This was especially worthy of note in checking the cooling curves. Mr. Hiorns had quoted a sample of silicon steel, mentioned by Mr. Adamson, as containing 0.8 per cent. carbon, combined carbon, and no graphite. He took it that Mr. Adamson there was quoting one of Mr. Hatfield's samples. There were steels sold in Birmingham containing 2 per cent. of silicon and 9 per cent. carbon, and these presented very remarkable properties. Of course, the whole of the carbon was in combination. In another portion of the paper sulphide of iron was described as a comparatively fusible body and as lowering the freezing point of iron. Would it not be better in that case to say that it extended the freezing range. The sulphide of iron, being the last to solidify, "widens the range of fusibility." Perhaps one of the best examples of the phenomenon of crystallisation he had ever read was that given by Mr. Hiorns, where he spoke of quick cooling or agitation of the mass on slow cooling producing small primary crystals. Mr. Hiorns gave in a few words a study of crystals. If Mr. Hiorns would permit him he should like to give a figure with regard to that. The figure was elastic limit 30 tons, maximum stress 40 tons, elongation 25 per cent. If the steel was slowly cooled they got this figure; but by cooling quickly, and producing small crystals that Mr. Hiorns mentioned, they could get an elastic limit of 43 tons, a maximum stress of 55 tons and an elongation of 20 per cent.

Mr. Pilkington was sure they would all agree that the paper was a very able one. Some of them had had the advantage of advance copies, and he hoped that on a future occasion all the papers would be printed, as that would enhance the value of their discussions considerably. (Hear, hear.) His point of view with regard to blowholes was somewhat different from that of some of those who had already spoken. He was glad to hear Mr. Buchanan say that ironfounders never blamed the pig-iron maker on account of blowholes. Unfortunately, that was not his own experience. (Laughter.) In cast-iron pipe-making they had another form of blowholes, due to imperfectly dried cores. Even in metal cast at a very high temperature they escaped them sometimes. But if the metal was at all dull the result was a lot of wasters. With regard to phosphorus and low carbon, some years ago he gave a number of analyses of the foundry pig and cinder pig, of South Staffordshire, where the phosphorus was about 3½ per cent., and the silicon comparatively low. Now, the carbons were particularly high in that case. He was glad that the author had mentioned the separation of graphite being largely a matter of time and attention, because they knew a few years ago they were in the habit of covering the red-hot pig-iron in the pig bed for the purpose of producing larger graphite crystals. There was the question of time and temperature, and of slow cooling. When they got iron in large masses it was the same thing. Mr. Hiorns mentioned manganese as assisting the chill. It was true that manganese did assist the chill, but it was a very different chill from the carbon chill. If they used manganese they had to be very careful indeed with the chill.

Mr. Mason wished more foundrymen would take advantage of the opportunity that existed in Birmingham for gaining metallurgical knowledge. He was sure those who had no metallurgical knowledge could not have followed the paper with half the advantage with which it had been followed by those who had such knowledge. When they had gentlemen like Mr. Hiorns and Professor Turner telling why metals behaved in certain ways when they were solidifying, they got some knowledge that their experience in the foundry did not always bring. In the foundry they saw certain things occurring, but their experience did not always explain the cause. When they were told about pearlite and sulphur, and that phosphorus caused the elimination of carbon, those were things that they met with every day, but the reasons for the phenomena they did not know. They were all troubled at times by the formation of kish and other things in the metal, which they did not understand, and which were often a source of great trouble and annoyance. All sorts of remedies were tried, but often without success. But, as the Professor had pointed out, the trouble was very often owing to high phosphorus. It was the same with regard to the troubles arising from sulphur. Sulphur got the blame for a great deal more than it was responsible for, simply because that was an easy way to explain trouble, but

very often sulphur had nothing at all to do with it. He was glad that the Professor pointed out that slight differences in the quantities gave widely different results, because on reading papers, it sometimes seemed that two men were saying exactly opposite things. It was quite obvious that when men did not work exactly on the same lines, even in a small matter, they could not expect the same results. If they did not take advantage of the teaching of the professors and of the teachers at the schools, then they were not up-to-date, and were only following rule-of-thumb lines. It was now time to get beyond that.

MR. SWINDEN thought that those who had differed from the conclusions of Professor Turner and Mr. Hiorns did so because they had worked under different conditions. The figures should be checked to see how they would agree with the results of ordinary moulding practice. With regard to the influence of the elements on segregation, Mr. Hiorns had told them that the segregation of one impurity often favoured the segregation of others, that when there was an appreciable segregation of manganese sulphur was generally present, and the segregate was therefore sulphide of manganese, and that the presence of chromium and tungsten favoured segregation, whilst the presence of nickel tended to prevent it and to make the casting more uniform. Here, of course, was the immense advantage caused by the presence of nickel, That, to his mind, was quite revolutionary, and he thought that the general evidence went to show rather that tungsten and chromium did not segregate, while nickel did to a very great extent. In the ordinary manufacture of high tungsten steels carried out every day in Sheffield with up to 20 and 22 per cent., there was practically no difficulty in segregation. One could make ferro-tungsten up to 30 or 35 per cent. without danger of segregation.

MR. MASON: How would you get on with a lower percentage, such as it used in cast iron?

MR. SWINDEN: I take it that with the lower percentage there would be still less risk of segregation. I have had some experience with 3 per cent. tungsten in steel and there has been no segregation.

MR. MASON: Have you had any experience with low percentages of tungsten or chromium in cast iron, such as would be used in the foundry?

MR. SWINDEN: Not in cast iron, but I have heard of no experiments showing that it behaves differently in cast iron. In the experiments of Professor Arnold and Professor McWilliam, published in 1889, tests were made with a core of steel forced into a tube of cast iron, so that there was very close contact between the two pieces. This was heated for ten hours at 1,000 degrees C., and then turned down. The layers close to the core were analysed, and in the case of tungsten and chromium there was no diffusion of the elements outwards. In the case of nickel there was distinct diffusion in the outside jacket to a distance of one-sixteenth of an inch. This seems to be a quite distinct proof. Manufacturers of armour plate, and so on, would only be too pleased to know that nickel did not segregate.

MR. HIORNS, in his reply, said that he was quite in accord with Professor Turner, because, in regard to the points which Professor Turner had raised, he (Mr. Hiorns), qualified his statement in subsequent paragraphs, for instance, with regard to the effect of phosphorus upon shrinkage. He thought there was one moral to be drawn from Professor Turner's remarks, and that was with regard to the non-metals. These must be kept within proper bounds and proper proportions. He thought, also, they all agreed that an element would act in totally opposite directions, according to the different conditions under which it existed in the mixture. With regard to Mr. Buchanan's remarks on blowholes, he himself did not know that there was any distinction in the foundry trade between pinholes and big holes. Of course, a blowhole, when it was sufficiently big, was a more serious matter than a pinhole, but he classed as blowholes any holes produced in metal by the action of gases; holes occupied by a gas bubble, and from which when cut through the gas escaped leaving a hole, the holes being of different shapes. He thought that Professor Turner would agree with him that in all their experiments the effects of making metal too hot was to increase the number of blowholes. The higher the temperature, the more gas the metal absorbed. Now when a metal had once absorbed gas, and had got it to be in what they called the occluded state, that gas, during slow cooling, would be largely eliminated. But under the rapid conditions of casting which now obtained, it could not escape. It remained dissolved in the metal if the elements were present under such a condition as to keep it in solution, but otherwise it would escape. Mr. Buchanan referred to the closing up of the moulds keeping the gases in solution, and attributed that to the pressure. But if they kept the top of the casting open, and liquid, the gases might escape. The fact was the gases tried to escape but could not, because there was a solid envelope formed by the surface cooling. The effect of closing up the top of the mould would be to keep the metal longer in a liquid state, and in that way might assist the escape of the gas. They must also remember that in steel castings they had the metal at an exceeedingly high temperature. In cast iron they had a metal at a much lower temperature. As a high temperature assisted in the absorption of gases, so with a low temperature, such as that of cast iron, naturally there would not be such an amount of gas present, and, therefore, not such a tendency to produce blowholes. With regard to the metals with low melting points, such as lead, they never had any blowholes; whether cast slowly or quickly they were always sound. With higher melting points he always got some blowholes, and, incidentally, he might mention gold as giving precisely the same results, having a high melting point, while copper was proverbially difficult to deal with in that respect. One absolutely could not cast pure copper without blowholes. They always had to doctor it up a bit in order to make it cast perfectly soundly. Mr. Pilkington's remarks about high carbon or low carbon were very interesting. His own experience was that high phosphorus always lowered the quantity of total carbon. Possibly, the large quantity of graphite in the samples mentioned by Mr. Pilkington might be thus explained. He (Mr. Hiorns might mention that he had specially arranged a course of seven or eight lectures at the Technical School for foundrymen, and he hoped that all of his friends in Birmingham would avail themselves of it. Referring to Mr. Swinden's remarks, of course, he (Mr. Hiorns) had not had any experience with things on a large scale like armour plates, and with these steel alloys, but they would readily understand that his remarks did not apply to ferro-chromium, or ferro-tungsten, or ferro-nickel, but to cast iron containing small quantities of those elements. The quantities in cast iron, he believed, were always extremely low. He did not know any cast-iron manufacture in which chromium and tungsten were specially introduced. They occurred only in very small quantities, and as impurities, and under these conditions probably segregation would be favoured. With regard to nickel, he knew that certain experiments were being made at the present time, and, therefore, he thought they had better reserve their conclusions with regard to its effect on cast iron. They would also, he thought, bear in mind the fact that every element under definite conditions always had

the same properties, and that the same elements under different conditions acted differently, and that every element, though having its own particular properties, could not exert those properties in exactly the same way if another element was present. The effect of a certain element in cast iron must be dependent upon the neutralising effect of other elements present.

THE APPLICATION OF "RULE-OF-THUMB" AND SCIENCE IN THE IRON FOUNDRY.

Mr. S. G Smith then read the following paper:—

The following is an extract from an article which appeared in the FOUNDRY TRADE JOURNAL of December last:—

"The finest 'rule-of-thumb' workers are daily confronted by an absolute failure of their pet rules and best efforts to produce a good result. To the best of their knowledge no change has been introduced, yet castings fail; it is here where the foundry

MR. SIDNEY G. SMITH (CHESTERFIELD).

fails daily to satisfactorily answer the criticism levelled at it, and discloses its lack of technical ability amongst its workers."

I refer to this, and similar statements which are from time to time made, with a feeling that the writers must either lack experience, reliable information, or are unable to appreciate the conditions and circumstances under which foundrymen have to labour.

The term "rule-of-thumb" is not easy to define, and I do not wish to mince this matter. If it is intended to convey ignorance, chance, or guesswork (and such may be the accepted meaning of it), then it will raise many doubts regarding its application in the foundry. If the term is applied to foundrymen who have not had a technical or a higher education, I claim that whether they possessed that education or not, as foundrymen they must essentially be rule-of thumb men, because there is no method of education, other than moulding shop experience, that can teach a moulder his trade. If the so-called rule-of-thumb men were taken from the foundry, who would be left? If the purely technical and scientific men were left, would there be any castings produced? What are the pet rules and failures mentioned above? Where does the foundry fail daily to answer the criticisms levelled at it? Can any part of such a statement hold good in the face of the fact that to-day there are more complicated and difficult castings successfully made than ever before? When we consider the searching inspection and exacting tests to which they are subjected, I say it is to the credit of the foundry that their failures are so few. Most of them arise either from circumstances over which we have little control, or the employment of men who are unskilled and inexperienced, consequently not rule-of-thumb men. It is necessary to combine acquired moulding experience with the most advanced technical and scientific practice to obtain efficiency in the foundry.

Now, I suggest that foundry "rule-of-thumb" practice is more or less scientific. That may be considered illogical, or it may be thought that I am disparaging theoretical and scientific knowledge, but that is not so. The meaning of the word "science" is knowledge reduced to a system or reducible to practice; a body of truths or principles. "Abstract science" is the knowledge of reasons and their conclusions. "Natural science" is the knowledge of causes and their effects. Now, science is the outcome of experience, proven and made fact, and in the foundry a moulder's whole knowledge is so gained. Book knowledge upon foundry work is very limited, and the practicability of what there is is doubtful, except metallurgical and chemical works relating to foundry matters. These may be valuable if compiled by men who have had foundry experience, but there is a difference in experience obtained in a laboratory and model workshop, and experience gained under actual foundry working conditions. Apart from elementary education, under which may be included drawing and geometry, there is a lack of book knowledge. But that knowledge, if available, would not be of any great value to the moulder, owing to the absence of important details, manipulations, etc., and it will ever be so on account of the continual changing of circumstances and varying of conditions which exist in foundry work. The most profitable and useful foundry literature results from experiments and practice by those who have operated under working conditions of foundry life; but even these results are not infallible, as such will alter under varied circumstances. The study and comparison of these, however, are a distinct advantage to the foundryman.

Design.

From a foundryman's point of view it is regrettable that the importance of design in relation to iron castings is so little understood by technical men, because bad designs involve internal stresses, which arise from unequal contraction and cooling, and affect the crystallisation during solidification, causing spongy, unsound, weak castings. One of the most important points is that the thickness be uniform as far as possible. That is to say, apart from solid bodies, where divisions are made by means of cores or otherwise, the thickness of iron forming those divisions should be as near as practicable the same. If there are different pressures and stresses to stand in different parts of the casting, the part requiring pressure should be made the required strength, and the parts that do not require to be made as strong from a technical point of view should be made the same strength from a practical point of view, in order to produce a sound casting. As an example may be

taken a casting of the jacketted type, in which, the writer contends, there should be little or no difference in the thickness of the metal of both walls. When there is a thin and a thick section there will be a difference in the rate of cooling, and also unequal contraction. This is undesirable at any time, but more especially in a complicated and costly casting. The outside wall, which should be thinnest, will solidify first, and as it cools its tendency is to draw and pull and rob the thicker and working section of its density and soundness. Also the unequal contraction of the two thicknesses may set up strains and stresses which would induce fracture. Many similar examples of faulty design might be enumerated, such as thick flanges or heavy sockets on a thin body, irregularities in stanchions, columns, pulleys, and gear wheels, etc.

Loam or Sand Moulding.

The question as to whether a casting should be made in sand or loam is decided by the shape, size, and the number required. Often when the number wanted does not warrant the expense of making a pattern it is more economical to make the casting in loam, despite the fact that it may be possible to make two castings in sand from a pattern in the same time as one in loam. There is an idea prevalent that where it is practicable to make a casting either in sand or loam, the loam method is much more costly than the sand. The writer, having had experience of both ways, is in many cases not quite in agreement with the idea. There are exceptions, but many of the castings now made in sand could be made in loam at the same cost, or, perhaps, less, and the castings would be better and cleaner. Of course, certain castings will always be made in sand, and for practical and economic reasons the same applies to loam, but regarding cost in both cases this depends upon the lay-out. In making a casting, whether in loam or sand, many matters have to be considered, such as thickness, machining, suitable sand, mixture of metal, shrinkage, contraction, etc. A most important matter is suitable tackle, which a foundryman has mostly to make for himself, and on a new job, either in sand or loam, it is wise to thoroughly think this matter out, as much time and money can be saved and lost by good or bad tackle.

Moulding Sand.

In selecting sand for facing, of which there are three or more strengths, varying chiefly in alumina, thickness of metal and depth of casting must be considered. Although a good blacking will resist the bite of the metal, when thick deep castings are made, a sand sufficiently strong in alumina must back it up to prevent fusion taking place with the fusible silicates in the sand. An experienced moulder can tell by touch which is the most suitable sand for the work in hand. The analysis of the sand in ninety-nine cases out of a hundred would be no guide, nor does the writer think it possible for a tabulated form of analyses to be of practical value for all kinds and classes of work. This may be done roughly, but with a casting of great thickness and depth the sand need not be so strong near the top half of the casting as the bottom half. This also applies to any casting of a given thickness where there is great depth, and in many cases where there is not great depth. I am not trying to decry analysis, but am endeavouring to show that in this case it is impracticable, and that more or less rule-of-thumb must prevail. Light work requires a sand that is low in alumina, heavy work requires a sand containing a higher percentage of alumina, while for very heavy work the alumina must be higher still. To the observant foundryman the "feel" of these sands are distinctly different. If I were asked to tabulate a form of analyses of sands for different thicknesses of iron, approximately it would be as follows:—For castings averaging 1 in. thickness weak sand containing 6 per cent. of alumina; for castings averaging 2 in. thickness, medium sand containing 8 per cent. alumina; for castings over 3 in. thickness, strong sand containing 10 per cent. alumina.

The silica will vary a little, but that is not important; potash and soda must be low, as these will fuse below the melting point of iron.

Coal Dust.

If a casting is made in green sand we add coal dust to the facing, but if made in dry sand or loam we do not, or should not, because in the two latter cases we wash with blacking. Some writers have recently stated that coal dust is used to make porous, strong, close sand, and that it burns out and allows the gases to pass off, and, also, that if an insufficient quantity is used and the mould is rammed harder than necessary, the gases cannot escape and blow-holes will be formed. These remarks are rather misleading. As a matter of fact, coal dust should only be added when the mould is green sand, or a skin-dried one. If it is added to dry sand work it is simply wasted, is of no service, and does more harm than good, as it increases gases of which there are already plenty to contend with in the mould. The coal dust is mixed with the facing sand, so that the sand will strip and leave a smooth clean skin on the casting. It does this by burning when in contact with the molten iron, creating a gas and forming a film which prevents the iron fusing the silicates, and so gives a clean bluish skin. This is the whole and sole object of adding coal dust. The amount of coal dust required in mixtures of facing depends chiefly upon the thickness of the casting and temperature of the iron when poured. Here, again, rule-of-thumb experience must prevail, as it would not be practical to work to a formula owing to the many varying conditions. In practice, we do roughly work to measures of coal dust per bulk of sand, which may be often altered to suit the work required. In many instances it is unwise to have the same amount of coal dust on the top part of a casting, as the other parts, so that if we had a formula for different thicknesses of iron it is obvious it could not be a fixed one.

Composition of Iron Mixture.

Mixing iron for different classes of work by analysis, fracture, and physical tests, has often been discussed. I do not propose now to enlarge upon this subject to any great length, but contend that it is unreliable to depend absolutely upon either of these alone. The three should be taken together, for to depend upon either of these alone may be deceptive. From different sources I have compiled a number of analyses of pig-iron, from No. 1 to 5, mottled and white. It is as well to know what the chief compositions of these are. Each of these numbers present a different fracture, from a large open graphite to a fine close grain. They also vary in colour from a dense sombre hue to a chalk white, and in varying degrees from a soft and tough to a hard and brittle iron. It matters not whether they are hematite, hot or cold blast pigs—these characteristics are more or less apparent. Also these numbers differ in analysis.

It must not be overlooked that variations will occur in fracture, hardness, contraction, and mechanical tests, no matter how near we may keep to analyses, and these variations will chiefly depend upon the temperature of the iron when it leaves the cupola, also when the casting is poured, thickness of section, rate of cooling, blast pressure, fuel, fluxes, and cupola control.

Influence of Metalloids and Manganese.

Carbon in its two forms is the important determining element of weakness and strength, and is influenced by the content percentages of the other metalloids regarding its form and action. Combined carbon increases shrinkage and chill, imparts softness, and shows a closer grain. Graphitic carbon shows an open grain, reduces shrinkage and chills and indirectly softens the iron. Generally speaking, most grades of iron, from hard to soft, are dependent on differences in the percentage of the combined and graphitic carbon. Silicon has a tendency to change the combined carbon into the graphitic form, thus resulting in a soft iron. Phosphorus gives fluidity, favours clean iron, and is said to reduce shrinkage. With high silicon a fluid iron will be produced, but it has little strength. Sulphur has a strong affinity for iron; it hardens and increases shrinkage and chill by a powerful influence upon the carbon, changing it to the combined form. The influence of manganese upon the carbon is to make it assume the combined state, hence it increases the chill, stiffens the iron, and, consequently, reduces deflection; it partially eliminates sulphur, and is considered to give the best results when its content is under 1 per cent.

Having acquired some knowledge of the composition of iron, and by experiment some idea of the influence of the metalloids, does not, however, give us that control that we wish. To those who have experience with different brands of iron, such as those made from English ironstone and ore, from foreign ores mixed with English ores and stone, and made by hot or cold blast, charcoal and Swedish irons, etc., it must be apparent there is a greater difference in the strength, toughness, and tenacity than the analyses would indicate. Take, for instance, a No. 1 or 2 Scotch iron with its extreme softness. I have not seen any English No. 1 or 2 that gives that quality of softness; the analyses of both are nearly the same, or if you will make them the same, the difference in the softness still remains. Again, a No. 2 hematite with its tough malleable nature is quite different from the other irons with analyses almost the same. Hot and cold blast irons do not show a wide difference in analysis, but there is a difference in the quality of the iron. From appearance, the graphitic carbon exists in a much more finely divided state in cold blast than in hot blast iron, which makes the matrix more uniform. With charcoal Swedish irons the low contents of impurities evidently account for their great strength. This would indicate that there is much that analysis does not yet accounted for. I mention this here, in defence of some who still think there is something to be said in favour of judging by means of the fracture of pig cast in the ordinary way.

Silicon Control.

It is fairly common knowledge that for thin castings the silicon content should be high, to give the desired softness; and to produce closeness and stiffness in thick castings the silicon should be low. For ordinary work the following tabulated system is good, and well worth consideration, and has been more or less the calculations for some years past:—

For castings under $\frac{5}{8}$-in. thick the silicon content desired is 2.55 per cent.

For castings averaging $\frac{7}{8}$-in., for machine parts, the silicon content desired is 2.40 per cent.

For castings from $1\frac{1}{4}$ in. to 2 in. thick the silicon content desired is 2.25 per cent.

In each case the combined carbon is 0.40 per cent., graphitic carbon, 3.10 per cent.; manganese, 0.40 per cent.; phosphorus decreases from 0.90 in the thinnest to 0.60 per cent. in the thickest; sulphur increases from 0.08 per cent. in the thinnest to 0.10 per cent. in the thickest. Thus sulphur increases and phosphorus decreases as the silicon content is reduced. Although we may not agree as to the large percentage of silicon, it appears to the writer to be a foundation stone for the groundwork for a system of standardisation by analysis.

It appears to me that silicon is the most convenient form of control. Personally, I wish iron contained no silicon, and that we had something better to control the carbons, for although its presence softens, it is only through its influence in increasing graphitic carbon, which breaks the continuity of the matrix. It does not necessarily toughen the iron. But to come to the practical part of working on lines of relative silicon content and thickness, it appears to me it will be best applied in its entirety to foundries engaged in specialities. In a general foundry casting many thicknesses during the day, one would need to be continually changing the charges of iron, or it would be necessary to pour castings of the same thickness at stated times. The other alternative would be more cupolas, and that would entail a greater cost, which at the present time we cannot afford to overlook.

Cupola Practice.

In melting iron in a cupola there are many varying conditions to contend with, such as pressure of blast, quality and quantity of coke and flux, method of charging and amount of the same. I often think the cupola does not receive the attention it should do, and am of the opinion that large sums of money may be lost owing to lack of proper attention. This is a phase of foundry work that lends itself to scientific control. An insufficiency or an excess of coke, flux, or blast means a dead loss, and results in either a sluggish dirty iron, with a large percentage of slag, or otherwise, an iron that has been deprived of its silicon, is high in sulphur, and, consequently, hard. I give particulars of a cupola which is daily in blast, and which I consider is fairly economical:—

	Ft.	In.
Diameter of shell	8	0
Diameter of lining...	6	0
Diameter of well	4	0
Distance from bottom to tuyeres ...	36	
,, ,, slagging hole ...	24	
Diameter of blast main	24	
Number of tuyeres	7	
Size ,, ...	9 in. by 4 in. (semicircular ends).	
Area of fan outlets, equal to	24 in.	
Revolutions of fan	1,000 per minute.	
Diameter of fan casing ...	5 ft. 9 in. by 12 ft. wide, driven direct with 30-h.p. motor.	

Blast pressure, 8 oz. by mercury gauge.
Weight per charge of iron, 1 ton.
Limestone, 28 lbs. per charge.
Coke, 1¼ cwts. per charge.
Melts 100 tons per day.
Self-charger by means of lift and shoot.
Total cost of labour, 5d. per ton.

I do not hold with being too sparing with coke or flux. Therein lies as much danger of loss as going to the other extreme. Some may congratulate themselves upon the low percentage of coke used per ton of

iron, but an analysis of the slag would often prove a revelation. I am inclined to think it would contain more than 5 per cent. of ferrous oxide. Also the upper parts of castings made with iron melted with a low or poor coke are not sound.

One other matter must not be overlooked. Very seldom do two cupolas work exactly alike and give the same results. I know of two cupolas which stand side by side, are the same in measurement, and identical in tuyere arrangement, area, etc., and yet one of them will give better results with less blast than the other. A capable cupola man will study his cupola and obtain reasonable control.

Smaller Charges.

I agree there is something to be said in favour of Mr. R. Moldenke's contention, that smaller charges are advantageous. Perhaps all the evils he mentions would not disappear, but there is reason to believe they would be minimised. The writer is of the opinion that 20-cwt. charges of iron are large enough for cupolas up to 60 in. diameter; that 1¾ cwt. of good coke per ton of ordinary iron is not too much; that 25 lbs. of good limestone is sufficient per ton of iron; that 8 to 12 ozs. of blast, as shown on the mercury gauge, is strong enough for cupolas up to the diameter just named; that one row of tuyeres is better than two; and that a few large tuyeres are better than many small ones. Of course, there are conditions where these remarks will not apply, such as with special irons, and very high temperatures. Providing the fuel is satisfactory, undoubtedly most of the troubles of cupolas, such as slow melting, hard, dirty iron, etc., have their origin in indifferent charging. If the melting zone is continually altering its position any of the troubles mentioned may be expected. An important point for the cupola man to watch is that the coke bed is the right height above the tuyeres before charging and to keep it there throughout the day. I have many times noticed when the blast has been put on at 6 a.m. the cupola has gone well until 2 or 3 p.m., then the iron comes down much slower, and the tuyeres are inclined to clog. I attribute this to the gradual lowering of the coke bed on to the tuyeres. A close watch should also be kept upon the slag as it is a good indication of how the cupola is working.

Feeding Castings.

There are few things more important than the judicious use of the feeding rod. Some moulders seem to regard feeding as a superfluous operation, and quite unnecessary when the mould is full of iron. This peculiarity is more pronounced when the weather is very hot. However, feeding is important, and where there are heavy and irregular bodies judgment and care are necessary. If the casting is cylindrical and vertically cast, which is the simplest form for feeding, the feed head should never be less than the section of the casting; rather thicker would be better, and the depth of the head should be according to the length and general thickness of the casting, and it will feed sounder if larger at the top than at the root. No hard-and-fast dimensions can be given for a feeding head, unless the conditions are known, but it is better to err on the heavy side. A polite disregard should be sometimes indulged in when complaints from the machine shop are made regarding the largeness of the head. It is a simpler operation to machine a little off than to put it on.

It should be remembered with steam and hydraulic cylinders and many other kinds of castings where density is required, the way to ensure this is to arrange the head of sufficient height, as the denser part of the casting is always at the bottom, and will decreasingly vary in density nearer the top. Of course, the feed head should be fed with rods that will ensure the top part of the casting being sound when the head is cut off.

With reference to work which is cast in a more or less horizontal position, and requires feeding the same principle must be borne in mind, *i.e.*, soundness underneath the feeders or risers. I have at times had occasion to alter from the usual rule the position and height of feed risers, which were not satisfactory owing to a thick and thin section being in close proximity. In regard to this we have sometimes to adapt ourselves to the design. I have sometimes seen a large quantity of iron flowed through many risers just above the level of the cope when one or two of sufficient height would make the casting sounder.

To sum up, the main features of the foregoing rule-of-thumb methods, born of experience, still hold good in many of the operations in daily foundry work. Design of castings is a matter that should receive more attention. Foundry and pattern shop foremen should work in conjunction. The manipulations in mixing iron are important, and there is ample room for the assistance of the chemist, metallurgist and the man of experience. Cupola practice is well worth the attention of all concerned in the management of the foundry, and periodical analyses should be taken and recorded of all that goes in and comes out of the cupola. The technical man cannot afford to say to the practical man—"Your experience does not count for much, by reason that it is not based on science." The practical man should not ignore the technical man, but acquire from him all that he can apply to his trade. To obtain the best results in the foundry the practical technical and scientific men should work hand in hand.

Discussion.

The PRESIDENT remarked that one of the greatest difficulties in the formation of the Society was the obtaining of papers from practical men, and the number they were now getting was due in a large measure to the educational efforts of the Association. Every year produced better papers from practical men, and Mr. Smith's paper was a great advance on any they had previously had. The writer referred to himself (the President) with regard to blast pressure, and the results he had obtained by its regulation. He had always tried to clearly define what he meant by that, because otherwise with many problems they got different results from what they were led to expect. He got harder effects in the metal by means of greater blast pressure; but he had also explained that that was obtained only under very exceptional conditions. Mr. Smith had spoken of melting 100 tons. If he started with 10 ozs. pressure, and put it up to 16 ozs., probably his metal would be harder, but that would be only for a short time. Afterwards, he would get very much softer iron. It was generally known that when blast pressure was put up, for a time they got a cooler hearth, and, therefore, harder iron. But in a very short time the furnace recovered itself, and they got a much greater temperature in the furnace, and, therefore, softer iron. The results he had always stated had been obtained with a special pig-iron at the end of a day's blow. The usual practice was to empty the cupola of ordinary metal, and then to make up a bed and put on the special pressure. The blast pressure was then regulated according to the work in hand. If they had a thicker cylinder they put on more blast pressure, and got a harder result. By putting on more blast pressure, they, of course, got a greater pressure in the cupola

and with a high temperature the carbon would be increased while they did not lose silicon, but with greater pressure and greater heat they would expect it to be reduced. The reason they reduced the carbon in the cupola was that the hearth was then somewhat colder, through putting new coke on. The flow was very short, perhaps not more than 5 tons. He took it that they burnt the graphite in the iron when it was in the pasty state, and they got a return of carbon. They would get harder metal at the end. With something like 5 tons under the conditions he had described, with a hearth somewhat colder, he had always got harder iron.

Mr. H. Pilkington said that Mr. Smith had referred to the designs of draughtsmen in the same sort of way that the foundrymen referred to pig-iron makers, and he (Mr. Pilkington) had a painful experience of the truth of the statements. He was often called in to arbitrate between those parties, and it was a difficult job. He had taken beginners from the drawing office through the pattern shop and through the machine shop, but they would not have the foundry, or if they had it would not tackle it for long. That was the difficulty in training draughtsmen, they seemed to fight shy of the foundry. Consequently there were very few trained draughtsmen who knew the foundry. There ought to be a closer touch between the foreman of the foundry and the manager of the drawing office. There was too much aloofness between the drawing office and those other departments, and he, for one, had been striving for many years to correct that. Loam castings, as against sand castings, had been mentioned by Mr. Smith. He agreed that they turned out much cheaper, and often made a better job. He understood him to say that combined carbon imparted softness.

Mr. Smith: No; increased hardness.

Mr. Pilkington said he thought that was an error. With regard to fine graphite and cold blast iron, he had already referred to that in connection with Professor Turner's paper. It was his good fortune many years ago to be acquainted with many of the people who made cold blast iron. It was most extraordinary how perfectly those men selected iron for cold blast purposes and chilled rolls, and they did it purely by the use of a delicate sense which enabled them to select by fracture. He did not want to say much about grading by analysis, but he had for some time been struck by the reckless use that was made of analysis for particular pig-irons. There were certain things not quite explainable. Take, for example, a glazed pig-iron of one brand which would glaze at 4 per cent. silicon and another which would glaze at 5 per cent. silicon, and they could pretty well understand where the point came in. Or they might take a certain North Staffordshire iron which possessed very low carbon, and with a precisely similar class of iron and a similar analysis in another county, they would produce nearly half as much more carbon. It was very rash to draw an inference from one district in that way, because the conditions or results in another district might be quite different. Another thing he would suggest was that when they referred to analysis they should be careful to say whether they were talking about analysis of pig or analysis of castings. There was a decided suggestion of confusion in some of the papers in regard to that. He cordially agreed with what was said in regard to the cupola and blast pressure, and was glad to find such moderate figures as 8 to 12 ozs. Those accustomed to melt large quantities preferred a large amount of tuyere area and very little pressure.

Mr. Carrick thought that the author of the paper had expressed what was in their minds with regard to the relation of theory and practice. He had referred to the use of silicon content as being a good guide to the mixing of iron. But it was a very difficult matter. He had personally for some time been varying the silicon content by the use of ferro-silicon in the ladle. Ferro-silicon containing 75 per cent. of silicon was put into the ladle for extra thin work, where extreme softness was required, and they found a distinct advantage under those conditions. He was also very glad to note Mr. Smith's reference to the value of lighter charges. There had been too much aiming after heavy charges, and that had caused a lot of cupola trouble. With regard to the question of design, they, as foundry foremen, had difficulties with the draughtsmen.

Mr. Buchanan said it was refreshing to find one standing up for the rule-of-thumb man, but he must be a rule-of-thumb man as defined by Mr. Smith, because that man was a man of experience. His defence of the rule-of-thumb man was based on the ground that foundry rule-of-thumb practice was necessarily scientific. However influential a man might be, he could never get successful results unless he worked along with natural or scientific law, recognised or unrecognised. The function of the Association was to get from the practical man the recognition of the laws under which he was working, so that he might the more thoroughly use those laws to his own ends. They were simply desiring that the so-called rule-of-thumb man should recognise the laws that he unconsciously observed and which dominated his own work, and should bring into play the forces which should serve his purposes. They were quite in accord as to the value of the rule-of-thumb man, and they agreed also that the rule-of-thumb man and the practical foundryman as they had him in this country, had no superior in the world. But with advancing information, they wanted to keep in front and to progress.

Professor Turner said that although he was not a practical man he would like to add a word on the paper. It might have been well if they had commenced with the definition of rule-of-thumb. It was referred to but not actually defined, and he did not know any expression which had been more turned from its original meaning than the term rule-of-thumb. When they proceeded to take hold of something, the rule-of-thumb meant that the thumb met the four fingers, and had a power of grasp equal to the four fingers, so that the rule-of-thumb was the rule of skill. If they applied the rule-of-thumb they made one man equal to the work of four, as the one thumb met the four. (Laughter.) On that system when they furnished the one with a combination of science and practice they got the true rule-of-thumb, and one man with the knowledge would do as well as four men without the knowledge. (Laughter.) The question had been raised before as to the differences between metals of the same composition. It was suggested that although they had the same composition they got different properties in the products. Mr. Smith had referred to the case of Scotch iron. For example, they had Scotch iron which was a very soft iron, and when they took a similar metal from another part of the country it was relatively hard. It was, therefore, suggested that there was something inherent in the Scotch iron not accounted for by analysis; in other words, they had so much carbon, silicon, sulphur, phosphorus, and manganese in each of the irons, but in the one iron from the north of the Tweed they had a property in addition, which they might call Scotch. But he thought if they searched a little further into these cases they would find out that that element of character was explainable. He had really given it a name for the moment, but that was merely to cover their ignorance; it was not that the two things were identical, though they thought they were. Either they contained some

things not allowed for, or they had been treated in a different manner.

Mr. R. Mason said that with regard to limestone, Mr. Smith had mentioned 28 lbs. of limestone per ton melted as sufficient, but they should not get too low a proportion of lime. Personally, he had found that quantity far too low, and it was really impossible to lay down a rule applicable to every case. If they had a large amount of light scrap to melt, or a great deal of sand, 28 lbs. of limestone would not flux it up. Probably Mr. Smith's scrap was heavier work, and, therefore, they would not get so much sand. In his own experience they required from 40 to 44 lbs. A good deal depended on the coke. As to the refusal to accept the statement that the cupola was a mystery, Mr. Smith had cited a couple of cupolas working side by side and giving different results, which certainly suggested a mystery. Mr. Smith also suggested with regard to the thickness of inside walls, that they should be equal to the outside. But his own view was that in most cases the outside should be thicker. The inside walls being kept hot longer by the jacket took longer to cool, and so the inside wall should be thinner to secure a regular rate of cooling. It was very desirable to make the two walls cool at the same rate. A good deal was said about alumina in the sand. Alumina was a big word, but if the chemist would call it clay they would know better where they were. The chemist sometimes in analysis dealt with alumina only. Alumina was not always clay in the sand, but in their work it was clay.

Mr. Smith, replying on the discussion, said that if there had been more time no doubt the discussion could have gone on for some hours. It had been a pleasure to give the paper, specially in a city like Birmingham, where they had that wonderful system of education. Personally, he was not altogether a stranger to Birmingham. With regard to blast pressure, he was rather surprised to hear that Mr. Cook did not lose more silicon in the increased blast, and that the silicon remained about the same.

The President: In a solution of 1½ we do not lose more than 1 per cent.; the solution is low to start with.

Mr. Smith, continuing, said that with regard to draughtsmen and designers, the training of draughtsmen was a most difficult matter to deal with. The question was how the training was to be got. A six months' acquaintance with the foundry was absolutely useless. But some of them did not get that much, and others did not get any at all. The time spent in the foundry should not be under two years, and the time would be well spent. He would learn more in that time than in fifty years outside. Mr. Carrick had spoken of silicon control with ferro-silicon. He had sometimes himself dabbled with silicon, manganese, titanium, and spiegel, but more in the experimental form. He understood that ferro-silicon could absolutely change the grain and grade of the metal the cupola was running on. He had done it himself, changing number two into number four. It was a matter of knowing how to manipulate those things. Professor Turner once referred to ferro-alloys as "a medicine chest." No doubt it was a good thing to have a medicine chest, if they knew how to use it, and though it was rather to be regretted that it was required, there were times when it was useful. For example, if they wanted to cast a No. 3 iron so as to get a stronger metal, a little manganese would do that. There could be a great many uses for ferro-alloys. With regard to limestone, he did not suggest hard-and-fast lines, and there were conditions when 28 lbs. of limestone would not apply. His figures of 28 lbs. applied to moderately clean iron and clean scrap, not to metal where there was a lot of sand adhering. Where they had sand adhering to an abnormal extent, they would need more flux, and perhaps have to go beyond 28 lbs. But if the coke contained more than 8 or 10 per cent. of ash, that needed fluxing as well, and so they got into difficulties by having to flux the coke. The best thing was to work clean iron.

The following paper was then read:—

INTRODUCTION TO THE EFFECT OF STRUCTURE UPON THE PHYSICAL PROPERTIES OF CAST-IRON.

By F. J. Cook and George Hailstone.

During daily foundry practice with work made from mixtures of iron to have the same chemical composition, and where tests are frequently taken, it is often found that widely different physical results are obtained, although the ultimate chemical composition of the metal used has been practically the same. Instances of this have been brought to the notice of the British Foundrymen's Association, notably in the paper read by Mr. Longmuir on "Theory and Practice," at the Sheffield Convention, when he gave several instances in proof of this. A remarkable instance was also given in last year's Presidential Address; but in neither case was any explanation of the phenomena given. Attempts have been made by several persons to give a satisfactory explanation of these differences, but, on the whole, the conclusions arrived at have not been generally accepted.

In the past, the instances cited have generally been isolated ones, but a remarkable series over a lengthy period has recently been met with by one of the authors. Figure 1. is a diagram of tensile test results of two series of casts, each series representing the work of sixty consecutive days, with irons mixed to give the same chemical composition, but each series made up with different brands of pig-iron. That the chemical analysis was identical in each case, was proved by analyses taken from time to time which in each instance came out for all practical purposes alike. It will be seen on reference to the diagram that the highest tensile result in the "A" series was lower than the lowest result in the "B" series. A summary of the whole of the tests taken is shown in the following table:—

Table of Mechanical Tests.

	Tensile Test. Tons per sq. in.		Transverse test. Cwts. 1in. sq. bar, 12 in. centre.		Transverse tests. lbs. on 1in. sq. bar, 12in. centre. Keep's test.		Shrinkage in inches, 1in. sq. bar. Keep's test.		Hardness.		Blast Press. in ozs.	
Series ...	"A"	"B"	"A"	"B"	"A"	"B"	"A"	"B"	"A"	"B"	"A"	"B"
Highest...	12.9	18.3	28.5	32.25	550	575	0.182	0.180	68	78	15	16
Lowest ...	8.7	13.1	19.0	25.0	390	375	0.141	0.140	48	56½	10	11
Average	10.7	15.8	23.1	29.1	465	450	0.140	0. 55	57½	64¼	12½	13½
No tests taken ...	60.0	60.0	33.0	30.0	58	59	58	59	60	56	44	30

Each tensile test bar, 1 in. square transverse and hardness bars were cast relatively of the same size and on the casting they were to represent, while the ½in. transverse bars which were also used for the shrinkage test were cast separately by Keep's method. The transverse bars were cast 1½ in. square, machined down to 1 in. square, and tested on 12-in. centres. The

hardness test was taken by the drill method. On referring to the table, it will be seen that the results of the transverse tests on the 1-in. square bars also show a marked difference, as do the tensile tests. It will be noticed, however, that the average result of the transverse test on the ½-in. square bars is slightly in favour of the series which gave the weakest tensile and 1-in. square bar transverse results. This point will be referred to later. As the methods of manipulation and the chemical composition of the two series had been the same, it was thought that a microscopical analysis would reveal a cause for the vast difference. For the first investigation, a low bar of the "A" series, and the highest bar from the "B" series Fig. 3 the high bar from the "B" series. These show the size of the graphite in each case, the one having it in the form of long flakes, the other in very small flakes. Figs. 4. and 5. show the same surfaces etched with iodine and magnified 60 diameters. In the one case the large flakes of graphite are plainly seen in a matrix of cementite, phosphorus-eutectic, pearlite and ferrite; whilst in the other the graphitic carbon is scarcely visible and a closer structure is observed. Otherwise, there is nothing very remarkable to account for such widely different physical results.

The same surfaces were then treated on the lines laid down by Mr. Stead at last year's Convention, to bring into prominence the phosphorus-eutectic.

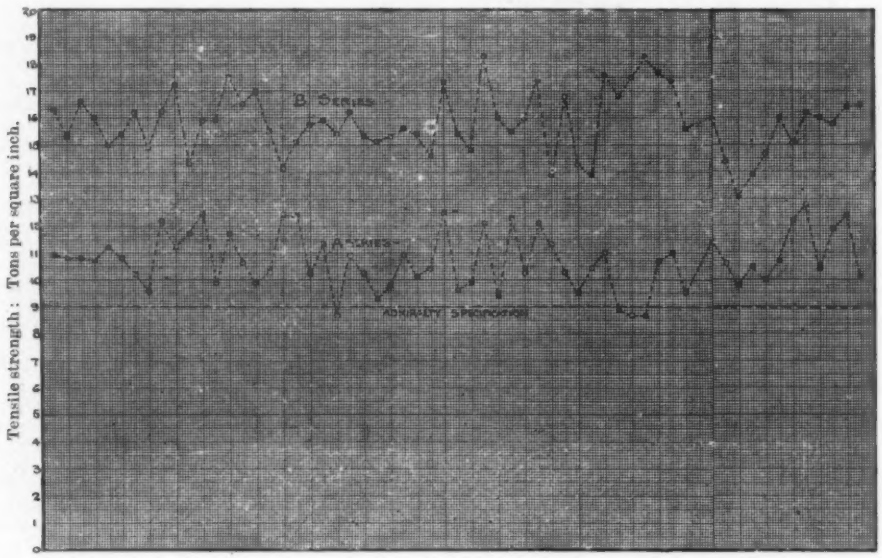


FIG. 1.—DIAGRAM OF TENSILE TEST RESULTS OF TWO SERIES OF CASTS.

were examined. The chemical analysis of the two bars was first taken and came out as follows:—

Series.	"A"	"B"
Tensile test.	9.1 tons per sq in.	18.3 tons per sq. in.
	Per cent.	Per cent.
Total carbon	3.250	3.192
Graphitic carbon ...	2.397	2.289
Combined carbon ..	0.853	0.903
Silicon	1.328	1.314
Sulphur	0 095	0.101
Phosphorus	0.923	0.909
Manganese	0.290	0.335
Iron by difference ...	94.114	94.149

These analyses will be seen to be practically identical even to the amount of the combined and graphitic carbon. To ensure the results being absolutely comparative, the following micrographs were each taken from the same position, *i.e.*, the centre of the bars. Fig. 2 shows the polished but unetched section of the low bar from the "A" series. Fig. 6 shows the 9.1-ton bar, and Fig. 7 the 18.3-ton bar. In both cases not only is the phosphorus but also the cementite shown. In Fig. 6 the phosphorus and cementite are evenly distributed, and had not taken up any definite form of structure, the graphite being also shown intermixed with it; but in Fig. 7 a very remarkable arrangement of a net-like formation of the phosphorus and cementite is shown. As it had been noticed with bars previously examined that those giving high test results had also been associated with this particular net-like structure, we were led to the conclusion that probably strength was associated with this structure independently of what the chemical composition might be. We therefore examined a series of bars made a few years ago to show the effect on strength of different rates of cooling. For this experiment, four bars had been made in one box cast from the same ladle of metal which was ordinary No. 3 foundry pig-iron. The rate of cooling was regulated by means of cast-iron chills of different thicknesses placed in the moulds for three of the bars, the other having no iron chill. The bar without the chill gave a tensile test result of 8.1 tons per square inch, whilst the bar at the other end of the series broke at 15.2 tons per

square inch. These two bars were selected, the chemical analysis of which was as follows :—

	Unchilled bar.	Chilled bar.
Tensile strength.	8.1 tons per sq. in.	15.2 tons per sq. in.
Total carbon	3.284	3.280
Graphitic carbon .	3.190	3.190
Combined	0.094	0.090
Silicon	3.366	3.368
Sulphur	0.025	0.026
Phosphorus	1.522	1.524
Manganese	0.231	0.230
Iron by difference ...	91.572	91.572

These results are identical, and as there is practically no combined carbon present, there must be an absence of cementite. The bars are also totally different in chemical composition from those previously examined. Figs. 8 and 9 show unetched sections from the two bars, with the difference in the formation of the graphite as previously pointed out in connection with the other bars, *i.e.*, elongated flakes of graphite in the unchilled bar, and finely divided graphite in the chilled one. Figs. 10 and 11 show the formation of the phosphorus eutectic to be in the case of the weak bar broken up and having no distinct pattern, whilst in the case of a strong bar there is clearly shown that net-like formation which was the distinguishing feature of the strong bar from the "B" series; but with this difference, that the structure was rather smaller. As there is no cementite present in this specimen, it is proof that the particular formation is not dependent upon cementite.

There was next examined another bar from "B" series. This had a tensile strength about half-way between the two bars previously selected, and had given a tensile test result of 13.9 tons per square inch. The analysis of this bar was :—

	Per cent.
Total carbon	3.272
Graphitic carbon	2.740
Combined carbon	0.532
Silicon	1.307
Sulphur	0.111
Phosphorus	0.948
Manganese	0.330
Iron by difference	91.032

This showed that whilst the total carbon and other elements were practically the same as in the two bars previously taken, the graphitic carbon was higher by 0.35 per cent., and the combined carbon lower by 0.35 per cent. This was probably due to the fact that this bar had been cast on a much larger casting than the previous two. The size of the graphite in this bar is illustrated by an unetched section in Fig. 12 which shows that although it is smaller than that shown in Fig. 2 of the 9.1 bar, it is larger and more elongated than that contained in the 18.3 bar, Fig. 3. The phsophorus eutectic which is shown by Fig. 13 has the same net-like formation as associated with the previous strong bars, though rather less clearly defined, and appears to be getting into the transition stage between the two.

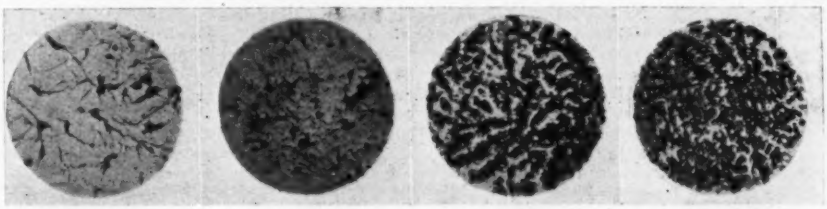


FIG. 2.
9.1 tons per sq. in. tensile.
Mag. 60 dias.

FIG. 3.
18.3 tons per sq. in. tensile.
Mag. 60 dias.

FIG. 4.
9.0 tons per sq. in. tensile.
Mag. 60 dias.

FIG. 5.
18.3 tons per sq. in. tensile.
Mag. 60 dias.

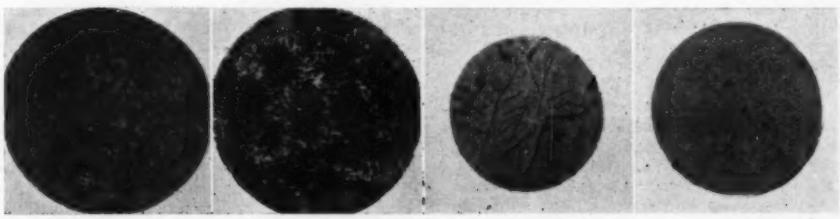


FIG. 6.—A SERIES.
9.1 tons per sq. in. tensile.
Mag. 15 dias.

FIG. 7.—B SERIES.
18.3 tons per sq. in. tensile.
Mag. 15 dias.

FIG 8.—UNCHILLED BAR.
8.1 tons per sq. in. tensile.
Mag. 60 dias.

FIG. 9.—CHILLED BAR.
15.2 tons per sq. in. tensile.
Mag. 60 dias.

The foregoing results, we think, have been sufficient to show that in each case high physical properties have been associated with this net-like formation of the phosphorus, also that the graphite when in the elongated form appears to split up the phosphorus eutectic and prevent this formation, as clearly shown in Fig. 6.

The question of the tendency of the graphite to take either an elongated or a finely divided form we think, is more a question of the way in which the pig-iron has been made, than of its subsequent

treatment in the foundry. The statement of Mr. Pilkington in this respect is very interesting, viz. :—

"Furnacemen have always been conversant with the fact that the temperature at which pig-iron leaves the tapping hole of the furnace has a powerful effect on its physical characteristics. The temperature of a large modern blast furnace is very much higher, and the metal therefore takes very much longer to cool than that which leaves the tapping hole of the smaller furnaces. Pig-iron from the extreme types could be made practically alike in chemical composition, but would behave physically in a different manner altogether, and would show very different grades, grains, and degrees of hardness."

On referring again to the summary of tests taken with the "A" and "B" series, it will be seen that the results of the ½-in. transverse bars of the "A" series, which gave weak tensile results, are slightly higher than those of the "B" series, and from this, together with the evidence of the chilled and unchilled bars made from low-grade iron, we are of the opinion that, with ordinary commercial pig-irons, no matter what their chemical compositions may be, there is a rate of cooling which will give high physical properties; the structure of the iron then being associated with the net like formation of the phosphorus eutectic and the cementite, when present.

It was said at that time by himself that if a commercial method of regulating the cooling of the castings, so as to obtain a fine graphite were devised, a tensile test could be regularly obtained up to 18 tons per square inch, or over.

The speaker, in giving a number of slides illustrating his remarks, explained that his object was to show the crystallisation of graphite and the net-like structure. While there was a gain in density and strength, there was also an inevitable decrease in other properties. Probably those low tensile bars would give better resistance to shock. It was obviously a matter which should be examined in great detail. They knew that with high carbon steel having that net-like structure of cementite, one could get exceedingly high tensile results considering maximum stress only, but if they took this high carbon steel and tapped it with a hammer, a piece would fall off, whereas if they took a low carbon without the net-like structure they could bend it double and smash it together, but it would not break. It had always been held that fracture travelled quickly through those cell walls, and, once started, it made progress. Those remarks were not intended as criticisms, but as an expression of views.

Professor Turner said that the authors had brought before them a very interesting communication, which opened up quite a field of investigation.

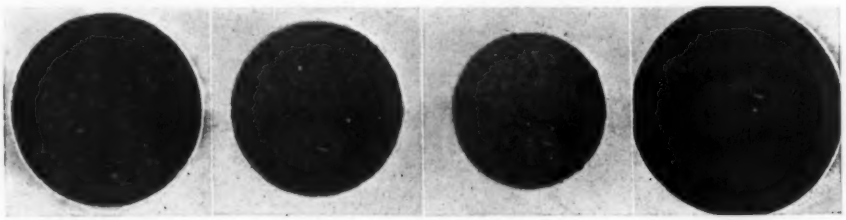


Fig. 10.—Unchilled Bar.
8.1 tons per sq. in. tensile.
Mag. 15 diams.

Fig. 11.—Chilled Bar.
15.2 tons per sq. in. tensile.
Mag. 15 diams.

Fig. 12.
13.9 tons per sq. in. tensile.
Mag. 60 diams.

Fig. 13.
13.9 tons per sq. in. tensile.
Mag. 16 diams.

It may be mentioned that as the time at our disposal since the commencement of this research has been limited, this short paper is only intended as an introduction to the subject.

Discussion.

Mr. P. Longmuir remarked that the paper was a distinct departure from the ordinary routine, especially as it brought in a spirit of research, and the authors, in the course of their research, had come across what appeared to be a very important influence. They had shown that a certain type of structure gave distinct mechanical properties. The question of graphite was one which he had examined some four years ago in a paper before the Glasgow and West of Scotland Institute, and he would now show a few slides illustrating its effects. The slides indicated that with an ordinary pig-iron the graphite appeared as long flakes, which acted as "cuts" when the iron was subjected to tensile stress. Taking ordinary Scotch iron with a fairly open grain, the long lines of graphite were fairly well shown, and if the iron was re-melted and poured into castings about 2 in. in thickness, they had the graphite taking a more or less larger form, while on re-melting, the change of the graphite was associated with a considerable gain of tensile strength. With a still lower diameter—a ½-in. bar—a change in the graphite was observed. He thought they had made out their point, that there was a rate of cooling which would give high physical properties, and a special rate of cooling which would give the best physical properties, and that that structure of iron was associated with the small graphite which chemists had recognised for a long time, and also with the net-like structure to which the authors were giving special attention. With regard to the question of cell walls, he fully agreed with Mr. Longmuir that if the walls were sufficiently thick, there was greater density, and no doubt he was right also in saying that the metal was brittle. On the question whether those walls were sufficiently thick to give brittleness, he thought it quite possible those samples might have considerable resistance to shock, but that was a question which could only be settled by experiment. They enquired why those irons behaved in such a way. In the set of experiments, the series "B" was a better series than the series "A," because, apparently, the latter was a little too soft to give the best results. Its shrinkage was a little low. A little higher shrinkage and a little greater hardness would make it a better series. The question was, why was "B" better when the materials had been treated exactly the same. It was not a question of different treatment, because both had been melted and cast the same. The only important difference in the analysis was, that in the one case they had slightly more sulphur than in the other, and he believed the iron was at a point

where any difference of sulphur was extremely important. When they got in the neighbourhood of 0.1 per cent., the sulphur, especially when there was a low silicon, was important, and in that case the silicon was extremely low, being under 1.4 per cent. For ordinary castings they had a material which was very easily affected.

He remembered, the speaker continued, years ago receiving an American core made from one piece of iron, and also one made from another. The question was, why one iron gave a good core, and the other a bad one? The analysis was almost exactly the same, but there was a small difference in sulphur, and his own opinion was, that that just made the difference. They had in one case an iron which gave a fracture or structure just a little too coarse—a little too soft; if they could make that only infinitesimally closer, the result would be that instead of a coarse graphite, they would have a fine one, and he had no doubt that if they had added a small amount of sulphur to the "A" series they would have made them quite equal to "B." Possibly the authors would express their opinion. Something had caused the graphite to become smaller, and one thing was the sulphur, which was associated with a range appreciably high. In the next series they had the same chemical composition, but one was so chilled as to affect the combined carbon, so that it did not produce cementite. It produced a large change in the size of the graphite, and they had a stronger iron. Anything that would give the small grain graphite and a cellular structure would give strong iron. That might be produced by the rate of cooling, but he would not have predicted beforehand from analysis that the difference in the rate of cooling beyond the difference in the percentage of sulphur would produce this effect. But he would have said "these irons are extremely susceptible, and they are just at the point when very little variation will produce a very great effect." He believed that the metal was re-melted, and it had then forgotten all about the hole from which it was originally dug.

Mr. H. Pilkington said he was glad that they had come to the conclusion at last that with an ordinary commercial pig-iron, no matter what the chemical composition might be, there was a rate of cooling which would give high physical properties. The subject was very interesting to himself. Work on the lines which the authors had taken in hand, would prove of the highest value to the ironfounder. At the Glasgow meeting he called attention to that very subject. A quotation had been made from a paper on pig-iron, in which he called attention to the effect of the cooling temperature when pig-iron left the blast furnace, but the quotation had been used in a very different sense to what was intended. Now Mr. Cook had conceded the point that there was something in grading after all. The grading of pig beds was the ultimate expression of the physical state of the iron. He had been hammering at this subject for many years, and for a long time nobody took any notice of it. He believed Mr. Cook had hinted at the question arising from the large modern blast furnace, as compared with the small one. But it seemed to be conceded that grading was an expression of the physical state of the iron. The experiments made in connection with the Glasgow paper were made with transverse test bars, which he had now given up as being of no scientific or any other value. A test with a bar which was not machined, could not be measured. The only valuable test for cast iron was a machined tensile test with a proper grip, where there was a good pull at each end. In the tests (made by Mr. Pilkington) which were with transverse bars, there was no question of extraordinary way of casting until they pursued the quenching business. But in the quenching they raised the transverse bars from 30 cwts. unquenched to 45 cwts. quenched. They failed to produce regular results, and did not pursue further the experiments of transverse bars. Subsequently, they dealt with tensile test bars cast in the pig beds. But that was for another object altogether. When they came to No. 2 iron and No. 3 iron they found that a direct cast of that grade would produce nothing more than five or six tons. As they came down to No. 4 forge they got results which rather surprised them. It was obvious that there was more silicon and sulphur in the pig bed iron, and they would expect the same grade of pig beds to produce a lesser tensile test from the cupola. The explanation proved quite simple. They were casting at a higher temperature and cooling down. That lot were 1½ in. bars, and in the next cast they made them smaller still, and got higher results. It was simply the result of fine graphite. The bulk of the paper related to the question of the size of the graphite, but it was exceedingly difficult to produce from mixed iron just the same grade of softness in the two series of bars. He noticed that in the first series the mixture was from different irons in each case.

The President: There is only one pig-iron different, but there are three brands in the one series, and three brands in the second.

Mr. Pilkington said he did not know whether it was argued that that change of brand had anything to do with the matter. It seemed to him it probably would have to some little extent. He partly agreed with what was said with regard to the sulphur. The combined effect of a few of those constituents was to raise the combined carbon appreciably. But he did not attach so much importance as Professor Turner to the effect of sulphur. He had been working himself trying to produce cast iron of a higher tensile strength by hastening the time of cooling. He considered they had got some marvellous results, but he did not wish to publish a series of unfinished experiments. It was perfectly possible by hastening the cooling artificially to produce those high tensile results. Mr. Longmuir had made a point which he thought would not turn out to be correct, that those high tensile results would not be reliable. They had not yet got to the stage of hastening cooling in connection with pipes, and engineers would probably object to it. But he sincerely hoped that pipes would prove amenable to heat treatment, and that the hastening of the cooling would give a metal of greatly increased strength which was required for many purposes, and which did not interfere with the production of 8- or 9-ton metal.

Mr. Swinden (Sheffield) said that no doubt the paper was of great importance. There were various ways of considering the matter, and particularly as to whether the elements would exist in different forms. There might be crystallisation during cooling. There was the point also of gases in solution, and finally, the quality referred to as "body." All circumstances but the last could be modified by remelting. He was not aware whether irons had been tried, but in cases of steel such as those referred to by Mr. Longmuir, steels giving the same analysis could be made to stand different tests, and show particular characteristics even after remelting. There was a great deal of practical evidence in support of the belief that there was something not explained by the conditions he had enumerated so for as could be understood. He had had the privilege of examining lately certain blast furnaces in Sweden, and he was particularly struck by the smallness of the furnaces and the slow rate of working. The iron was simply splendid, but there was nothing great in the analysis, although looking through the books the analyses were fairly regular, a typical one being as follows:—Com-

bined carbon 0.2, graphitic 2.4, silicon 2.8, manganese 0.6 phosphorus 0.5, sulphur 0.15. They would see the phosphorus was very low, and the sulphur varied in the half-year from 0.13 to 0.17; the tensile tests were very seldom below 16 tons. One sample that the students saw broken at this particular works gave a test of 19.2 tons. The transverse tests varied in the results from 38 to 46 cwts., which was pretty good on a standard of 1 in. by 2 in. bars. They used the English bar test method. The amount of pig-iron produced in the year 1907 was 16 tons per day from one furnace. That was about four tons per tap, and the year's output was 5,840 tons. That would compare with the English practice in the big furnaces of about 100 tons per day, or more. It was very difficult to say in regard to the series given by the authors whether it was a case of crystallisation from the higher temperature. With the formation of graphite in the structure, a phosphide eutectic, or other structural constituents, it was difficult to understand why they got a parallel case. In other materials, such as steel, where they had not graphite or phosphide eutectic they got more mysterious cases, steels of similar analysis giving totally different tests. He did not wish to suggest that that in any way detracted from the value of the paper.

The CHAIRMAN, in replying, said the authors quite recognised the gain to be had from finely divided graphite, but the peculiar part was that in all the strong sections shown there had been that particular net-like foramtion as well, and they never had the small graphite without it. They were greatly obliged to Mr. Longmuir for his slides, these, howeer, were hardly comparable, for it was only when examining under low magnifications, and after deep etching that the net-like formation was seen. Mr. Longmuir is altogether wrong when he said it would not be safe to put that net-like iron into practice. Shock tests had been taken in a sense, when breaking up castings, runners, etc., from A and B series, the B proving by far the better iron, being very difficult to break with a sledge hammer, and showing a tendency to bend before breaking.

With regard to Professor Turner's suggestion as to the effect of sulphur even in small percentages, his (Mr. Cook's) own examination suggested that the sulphur had nothing to do with it, he quite agreed that the "rushing" of iron had a lot to do with lower quality, and he understood that in Sweden an attempt to rush the furnace had had the result, without altering the chemical analysis, of making a great change in the physical properties.

MR. SWINDEN: That is so.

The PRESIDENT: I think there is something in that. Continuing, he agreed with Mr. Pilkington on the importance of the rate of cooling. He (Mr. Cook) had shown in his paper on tensile testing that the rate of cooling had a marked effect, and they had the further fact that in the two series of tests the bars were treated in exactly the same way.

They took the bars chilled and unchilled to see whether the net-like formation was still there, although there was no cementite and the chemical analysis was different. There certainly seemed to be somthing in this net-like formation of the eutectic. Although there was cementite in the one case, they did not think it had anything to do with the formation,, because they proved the same formation with iron containing no cementite. On behalf of himself and Mr. Hailstone, he thanked them for the attention they had given to the subject.

This concluded the papers and the discussions, and the proceedings closed with a general resolution of thanks to the Governors of the University and Professor Turner for the use of the room, to the readers of papers, and to the local Committee.

Contributed Discussion.

Mr. Hiorns wrote:—

It has long been recognised that ordinary chemical analysis does not indicate physical properties, and the fact that two samples of cast iron having identical compositions may have quite different physical properties is a common experience of the founder; but the cause of this difference has not yet been fully explained. It is well known that heat treatment modifies the physical properties, and mechanical work has often an immense effect, but the latter condition is not operative in cast iron as cast. The cause of difference of properties has generally been attributed to an alteration in the condition of the carbon; either the graphite being changed from large to small sized grains or *vice versâ*, or the free carbon changed to combined carbon, or the opposite, combined carbon to graphite.

The paper clearly proves that under identical conditions the same result is always obtained, as shown by the series of casts extending over 60 days' work, the large-grained graphite giving lower tensile results than the fine-grained graphite. With regard to the phosphide and the carbide the authors point out an evenly distributed arrangement in the specimen with large graphite and a net-like formation in the specimen with finely divided graphite, and conclude that greater strength is associated with this form of structure. The thing that strikes one is the stationary condition of the combined and free carbon in both instances, so that the iron could not be in the gamma state in one case more than the other. It is not therefore a question of gamma iron making the difference in strength; but it does not show that the beta form, which does not dissolve carbon, may not have some influence. If in the stronger iron there is present the beta modification of iron, and in the weaker one the alpha form, that would account for the difference in strength.

I think it very likely that cooling curves would give valuable information as to the cause of the difference. It would be interesting to know if there was much difference in the mode of cooling in the A. and B. series. It has been generally noticed that tenacity varies with structure, and the authors have rightly attributed the difference in their two series to a difference in the structure. With regard to the combined carbon, the structure, according to the rate of cooling, may be pearlitic or martensitic, the latter giving a much higher tenacity than the former.

It seems a strange, and I think a dangerous, doctrine to assert that the strength of commercial cast irons is independent of chemical composition. It is true that a certain structure gives a higher tenacity than another; but two irons of different chemical compositions may have the same structure and practically the same tenacity, but vary considerably in brittleness, as is the case with irons containing, say, nickel or phosphorus. Take the chilled bar (15.2 tons), with 3.37 per cent. silicon and all the carbon in the free form, the point A_3 in the cooling curve is not observed, and the point A_1 practically coincides with A_2. Now take an iron with 1 per cent. silicon, which would show the point A_3 approaching the critical point of pure iron; the presence of 0.9 per cent. carbon would altogether destroy this point or lower it to that of about 700 degrees C. If chemical composition has no influence then the experiments made by Turner and others to establish its influence of silicon have no meaning.

With regard to rate of cooling, it does not matter what the rate may be below a certain critical temperature, but the maintenance of the iron for a long time within a certain range of temperature is all important.

The authors have made a step in advance in their paper, and if further investigation leads to the complete explanation of difference in strength of two chemically identical samples they will place the whole foundry trade under a deep debt of gratitude.

Mr. P. Munnoch wrote:—

The thanks of every chemist and metallurgist dealing with cast iron are due to the authors for bringing forward a paper on this subject. The results given are very interesting and instructive, and are very valuable owing to the large number of tests compared. The iron foundry chemist must assume, as a basis on which to work, that physical results can be controlled by means of chemical composition. In actual practice there are many exceptions met with which cannot be accounted for, and any explanation of the difficulty is very welcome. It is noticed that some brands of pig-iron give different results to others of apparently similar analysis. In most of these cases, a series of full analyses shows that there is a difference which an insufficient number of analyses, or analyses not sufficiently complete have not shown. In other cases the ordinary series of determinations, usually called a complete analysis, does not show any reason for the superior or inferior results obtained.

There are usually present in pig-iron several minor constituents, the small amounts of which, not being known to have any effect on the properties of cast iron, are not usually tested for; occasionally, however, there are present unsuspected amounts which may be sufficient in quantity to considerably alter the physical properties. There is also the presence of oxides and of occluded gases, the amounts and physical effects of which little is known. The authors' discovery in connection with the microstructure is very interesting, and is apparently proved by the examples and microphotographs shown. With regard to the ½-in. test bars of series A. and B., it would be of interest to know whether micro-examination of these confirms the results obtained with the 1-in. test bars.

The authors' explanation that the difference in the test results of irons similar in analysis is due to the temperature at which the iron is produced in the blast furnace, and that this temperature leaves an effect, unexplained, but evidently a physical effect, which is not removed by remelting, is an explanation which should not be accepted until it has been proved by a number of very full and complete analyses that the cast iron contains no unusual constituent, and also that the pig-irons used contained no such constituent, the bulk of which may have been lost during remelting, but which may have had some protective influence in the one case or detrimental influence in the other.

Owing to the time required and the expense of going minutely into such details, our enlightenment on the subject can only proceed slowly. If the authors' paper leads to more investigation into these difficulties, control in the foundry will soon stand on a more scientific basis than at present obtains.

Authors' Reply.

In reply to Mr. Hiorns' communication the authors wrote as follows:—We do not consider that the difference in strength is a question of alpha and beta modification, the pearlite being in the same form in each case, but we quite agree that possibly cooling curves might have given information that would have been helpful. The rate of cooling in both the A. and B. series was practically identical, the test bars being cast on commercial castings which were each treated in a similar manner. We do not assert that the strength of commercial cast irons is independent of chemical composition, but we consider it is equally dangerous to assert that strength always follows certain chemical composition, and therefore strongly advocate that the physical structure of the iron shall have equal consideration with chemical composition.

In reply to Mr. Munnoch:—With reference to the presence of large or smaller quantities of minor constituents, it is our intention to go further into this matter in the near future; the presence of oxides is a very debatable question, and we doubt if there is any really present. It is our intention also to more closely consider, analytically, microscopically and mechanically, the irons both before and after melting.

THE VISITS.

Visit to the Birmingham University.

Probably the most attractive visit of all was that to the new Birmingham University Buildings at Bournbrook, which took place on Tuesday afternoon. This magnificent institution was opened on July 7. The buildings, which are on a massive scale, have been erected at a total cost of £450,000, to which local magnates in the iron and steel trade have been generous contributors. The Birmingham University has for some years past, on the initiative of Mr. Chamberlain, paid special attention to commercial, business, and technical equipment, so that students qualifying for industrial careers are likely to turn their attention first and foremost to Birmingham. In this branch Professor Turner has taken a large share with regard to design, equipment, and arrangements generally. The metallurgical department has been in working order for upwards of four years. The engineering department supplies from its own power station electric current and Mond gas for use in the metallurgical laboratories. In the Museum, the visitors were able to see some rare specimens of metallic ore, special alloys and typical local metals. The place is well lit, a model of order, and lacking nothing in equipment for practical training. A special feature is the smelting laboratory, equipped with a large supply of muffles and testing rooms, with an ample array of pyrometers; a foundry a forge, and a small Siemens' furnace, with all the necessary equipments such as electric hoists, crane, boiler, ladles, moulds, metal stores, etc. There are also a water-jacket blast furnace, a roasting furnace, a cupellation furnace, a Bruckner calciner, a weighing machine, and a Roots blower. Naturally, there was a great desire to see the mammoth testing machine lately furnished by Messrs. W. & T. Avery, of Birmingham, which we described and illustrated in our issue of July last. At ordinary times, the students may be seen in their overalls engaged in actual moulding in the moulding shop, and twice a year the Siemens' furnace is put in operation and ingots are produced; of these a number were on exhibition. The visitors had the advantage of Professor Turner's guidance in their tour through the various departments, and the arrangements were the subject of a good deal of approving comment. The entire area of the University covers 44 acres, and its great clock tower rising to a height of 325 ft. is a conspicuous landmark for miles around. The grounds themselves are rapidly approaching completion, and are artistically arranged with slopes, curves, and well-laid paths.

About seventy of the members accepted Professor Turner's invitation, the visit being favoured with charming weather. After inspecting the imposing exterior they were welcomed in the Great Hall by Professor Turner robed in academicals, and each delegate was formally introduced.

Before the tour commenced the Professor offered a few explanatory words as to the University and its objects, remarking that the University authorities welcomed their visit. Calling attention to the Great Hall, which is a lofty and handsome building equipped with a fine organ and pictorial windows, the Professor mentioned that one of the windows was symbolical of metallurgy. The professors represented theory, while the foundrymen stood for practice, and they hoped to join the two. (Applause.) The University owed its origin largely to Mr Chamberlain, whose statesmanlike suggestions and influence assisted in getting the money. The area of land was given by Lord Calthorpe, and the last twenty acres had been laid out as a recreation ground. After describing the various features the Professor expressed the hope that the Institution would be of great value to Birmingham and the counties round.

Mr. Buchanan, on behalf of the local committee, offered a few words of welcome, and expressed the hope that the University would play a large part in the trade with which they were connected, as they might obtain a knowledge clamantly necessary in their business. He moved a resolution of thanks to Professor Turner and the local committee, which was seconded by the President (Mr. F. J. Cook). This was enthusiastically carried, Professor Turner acknowledging.

After the completion of the tour the visitors were entertained to tea in the basement refectory by the Birmingham Branch.

Summer Lane Electric Station.

In the evening the visitors re-assembled for a visit to the Municipal Tramway Generating Station, Summer Lane, Birmingham, which although one of the youngest of the city's institutions is already counted as one of the most useful and valuable of the Municipal properties. Like the University, it is built on a gigantic scale. Its inception is due mainly to the necessity which arose four years ago, of supplying the electric tramway which the city had just acquired. But before this a small electrical department existed which had been acquired from a private company. The works almost completely cover the site of 4½ acres occupied for 100 years or more by the old General Hospital. The works are among the biggest in the kingdom. The expenditure up to the present upon the works, cables, etc., has approached half a million, the cables measuring some hundreds of miles. There are three large buildings, each 275 ft. long, comprising the engine house, the boiler house, and the economiser house. Of these the engine house is the largest, being 100 ft. wide and so spacious that the Birmingham Town Hall, which accommodates over 2,000 people, could have been dropped into the building before it was equipped with its engines. In addition there is a workshop block, a switch gallery, battery room, mess room, etc., and a couple of stacks, the larger of which runs to a height of 230 ft., with a diameter inside of 15 ft. This structure alone consumed three-quarters of a million bricks, while the entire group took about six millions.

The electrical producing plant is constantly being increased owing to the rapid utilisation of light and power by Birmingham manufacturing firms. So many great engineering companies have had a share in the mechanical equipment that many of the visitors were able to look upon their own handiwork. For example, Messrs. Belliss & Morcom, of whose foundry Mr. F. J. Cook, the Foundrymen's President, is manager, had furnished nine large engines, of which four are of 3,000-h.p. The current generators are by the British Westinghouse Company; smaller engines by the General Electric Company; conveyer buckets by the New Conveyer Company; some of the largest generators by Dick Kerr & Company, Limited, and others by the Westinghouse Company. An important item is a travelling motor crane with a lifting capacity of 40 tons, supplied by Applebys, Limited. The switchboards are from the works of the Thomson-Houston Company, Limited; the big boilers by Babcock & Wilcox; and the steam pumps, by Allen, Son & Company, Limited. Naturally, the visitors were specially interested in the exceptionally massive castings, of which the flywheels of the direct-current apparatus weigh 25 tons. For the alternating current the wheels, which consist of iron castings with heavy cast-steel rims shrunk on, have a total weight of about 27 tons. The large boiler house accommodates 24 boilers, although these are not all yet in their places. In a way, the vast establishment should satisfy British patriotism, as the whole of the work is of British manufacture, not a single item having come in from abroad.

Visit to Belliss & Morcom's Electrical Works.

Wednesday afternoon was occupied with a visit to the large engineering establishment of Messrs. Belliss & Morcom, Icknield Square, Birmingham, special attention being paid to the electrical machinery department. The works are among the largest in Birmingham, and are situated about a mile from the heart of the city. The founder of the firm was Mr. G. E. Belliss, who came to Birmingham about the year 1825, and who was apprenticed to an engineer and boiler-maker in Broad Street. Shortly after the expiration of his articles, he acquired the business, and for many years carried it on under the style of G. E. Belliss & Company. At that time they devoted themselves to high pressure vertical fixed steam engines, contractors' locomotives, travelling portable engines, etc., but Mr. Belliss afterwards turned his attention with great success to the production of engines specially adapted for marine requirements, and this became the most important branch of the firm's productions. A specially light engine for steam launches was devised, which was approved by the Admiralty, and for many years Mr. Belliss had a practical monopoly in the provision of these engines for small pinnaces and cutters to the British Navy. In 1872, a more commodious establishment was found necessary in Ledsam Street, and still further extension was found necessary in 1897 owing to the great demand for the self-lubricating engines which are now their specialities. The system of automatic lubrication introduced in 1889 has gradually superseded the open-type engines, the principal advantages being greater durability, higher speed and efficiency, combined with economy and simplicity. The firm became a limited company in 1893, and Mr. Belliss himself was Chairman until his retirement in 1904. His death took place in February last. Much of the success of the concern was due to the efforts of Mr. Alfred Morcom, who gave up his position as chief engineer at Sheerness Dockyard in 1884 to join Mr. Belliss.

The enormous public demand for electrical machinery has furnished the Company with an opportunity of which they have not been slow to take advantage. The best testimonial as to local appreciation was the equipment of the Summer Lane Station mainly with 3,000 h.p. Belliss engines, and similar machinery is found in a large number of electric generating stations at home and abroad. To the members of the British Foundrymen's Associa-

tion, the foundry itself has a special attraction on account of its modern equipment, the great weight of castings turned out, and the fact that the foundry is under the management of Mr. F. J. Cook, the President of the Association. This department is large and extensive, equipped with powerful cranes, and every essential to rapid production of high-class castings.

The party were conducted round the works by Mr. Edgar Morcom, and at the close a hearty vote of thanks was proposed to the firm by MR. H. PILKINGTON, seconded by MR. LONGMUIR, to which MR. MORCOM responded.

In the evening a smoking concert, which was well attended and furnished an excellent programme, took place at the Imperial Hotel.

Visit to the Works of the British Thomson-Houston Company, Limited, Rugby.

The more serious business of the reading and discussion of papers having been completed on Wednesday, the following day was given up to visits and tours through Warwickshire, commencing with an inspection of the great works of the British Thomson-Houston Company, Limited, at Rugby. The 30-mile run from Birmingham brought the party to the works at the early hour of half-past nine, and the following three hours were devoted to inspection. The vast establishment is one of the best examples of modern British engineering. The works were built only nine years ago, the entire acreage being 25. They are pleasantly situated upon a rural area, with breezy and green surroundings. In addition to the great output of electrical plant, the firm furnish sufficient surplus electricity to supply the town of Rugby with its 20,000 inhabitants.

The most striking department which invariably makes a great impression on the visitor is the machine shop, 425 ft. long by 265 ft. wide. The place is a hive of industry, and equipped with the finest machinery. The mechanical qualifications are comprehensive, dealing with work up to 24 ft. in diameter. At the time of the visit a number of motors were being built for the equipment of tram cars. The firm have done a remarkable portion of the municipal work throughout the United Kingdom. The employés number nearly 2,000, of whom 140 work in the foundries alone, while the pattern shop employs 70 men. The ironfoundry has some excellent qualities, having a space of 275 ft. by 90 ft. in width, of which a section is devoted to brass and kindred alloys, the special metals dealt with being aluminium, phosphor-bronze, brass alloys of various mixture, and a number of special alloys. Much of the moulding is done by machinery, the moulding machines being of the Tabor description, with two Bonvillan machines. Castings of large size can be dealt with, and the travelling cranes lift up to 40 tons. Some fine work was in progress in the way of turbine casings, generator frames, and other motor parts. Special care is taken in analysis and general laboratory work, all materials being subjected to the strictest tests. There is also apparatus for sand mixing, and the preparation of materials generally. In the show room some switchboard work was to be seen, very well illustrating the fine finish and generally smart appearance of the Company's products. The entire concern is laid out for a large and increasing output of the very highest class of work.

At the close of the visit MR. COOK proposed, and MR. BUCHANAN seconded, a vote of thanks to the firm, which was acknowledged by MR. DENNIS.

A Warwickshire Tour.

The whole of Thursday afternoon was spent in a drive through the charming Warwickshire district, Leamington, Warwick, Kenilworth, and Coventry. Leamington was reached at one o'clock, and after lunch the visitors were driven to Warwick Castle. Leamington has charms of its own. It is a delightful residential suburb and a great centre of attraction for Birmingham. The discovery in 1808 of a spring of saline water by the village cobbler and poet, Benjamin Satchwell, was the beginning of its career as a health resort.

A different kind of interest attaches to Warwick Castle, while the town itself has preserved with wonderful fidelity the quaint Elizabethan character which distinguished it in Shakespearean times. The visitors seemed to have been suddenly transported from modern England to a strange quaint world of 200 years ago. Of course, the Castle has preserved its ancient character, and it has the additional special title to fame that it is also a modern residence occupied by the Earl of Warwick and his family, and a favourite rendezvous equally of the British aristocracy and of the industrial leaders who have so often been associated in social reform with the popular Countess. The Castle dates back to the time of Alfred the Great, and has a splendid history. Cæsar's Tower, the oldest portion, is 147 ft. high; Guy's Tower, built on an elevated rock, is still more imposing. The Great Hall has a wonderful collection of carving, armour and trappings of the famous Guy, Earl of Warwick. The Banqueting Hall is gorgeous with carving and gilding, and recalls in many ways the ancient splendour of the castle. Naturally, the great porridge pot of the giant Guy, used on exceptionally festive occasions as a punch bowl, claims special attention. From Warwick Castle the visitors drove to Guy's Cliff, the traditional home of Guy, Earl of Warwick, and now the residence of Lord Percy. This is also a fine Elizabethan building with natural terraces and grottoes. The journey was continued on to Kenilworth Castle, once visited by Queen Elizabeth under circumstances immortalised by Sir Walter Scott. The Castle is one of the most magnificent ruins in the Kingdom. Continuing, the party reached Coventry, and after tea visited St. Michael's Church, St. Mary's Hall, finding in all directions reminders either of ancient importance or of modern industrial activity. Of late years business developments have greatly added to the city's industrial activities.

Birmingham was reached by train about nine o'clock, after an exceedingly busy but interesting day; these visits concluding the Convention.

VEITHARDT & COMPANY, LIMITED, 26 and 27, Bush Lane, Cannon Street, London, E.C., have been appointed sole representatives for Great Britain and Ireland for the engineering department of the well-known firm of Thyssen & Company, of Muelheim-Ruhr, Germany, makers of rolling mill plant of every description, steam engines, compressors, rolling mill driving engines, blowing engines, pumping plants, etc.

GALLOWAYS, LIMITED, of the Knott Mill Iron Works, Chester Road, Hulme, Manchester, and the Branch Iron Works at Bennett Street, Ardwick, Manchester, have taken up the manufacture of the Ehrhardt & Sehmer gas engine in this country, the sole British agents of which are the Key Engineering Company, Limited, 4, Queen Victoria Street (Mansion House Buildings), London, E.C.

Moulding a Column Cap.

By W. F. Newlands.

A foundryman, when estimating for castings such as he has never previously dealt with will be fortunate, indeed, if he fixes upon the best method of making them at the first glance, or in the short time that is often at his disposal for looking over and studying the drawings or patterns. The following is a description of how it was first intended to make, and also the method ultimately adopted for making a

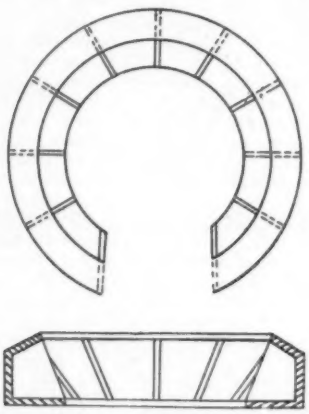


FIG. 1.—PLAN AND SECTION OF CASTING TO BE MADE.

number of castings used for ornamenting the top part of cast cylinders used as pillars or columns in the construction of a bridge. Fig. 1 shows a plan and section of the castings required. The sizes of the castings were about 12 ft. diameter (outside), 18 in. deep, 18 in. bottom flange, and 8 in. top flange. Eleven brackets were divided over the casting between the top and bottom flange. At the time of

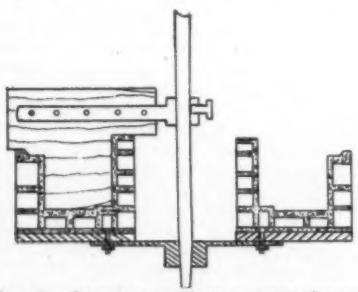


FIG. 2.—SECTION OF MOULD, WITH SWEEP IN PLACE AS FIRST INTENDED.

estimating for those castings it was decided to build the mould and sweep it up on an ordinary bottom plate, as in Fig. 2. The cores were to be made in an ordinary wooden core-box of the proper shape, and when dry, and the mould also dried, blacked and ready for closing, they were to be fitted into the mould, resting the inner part of the core on a bearing swept for that purpose and the outside part on chaplets, bolting them with hooked bolts onto the inside wall of the mould, as shown in Fig. 3. This is a section of the mould closed, and shows the plate and cores in place, and the method of bolting the cores by the core irons back onto the inside wall, as they would have appeared had this method been adopted. Had there been but one or two castings to

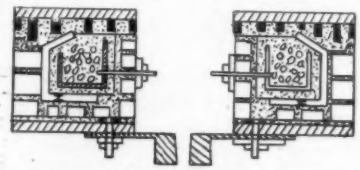


FIG. 3.—SECTION OF MOULD CLOSED, WITH CORES SET, AND SHOWING METHOD OF FIXING AS FIRST INTENDED.

make this method might have been as good, and perhaps as cheap a way as any, but on further consideration it was decided to discard the method just explained and adopt another, which was considered much better, and which in the end proved to be so.

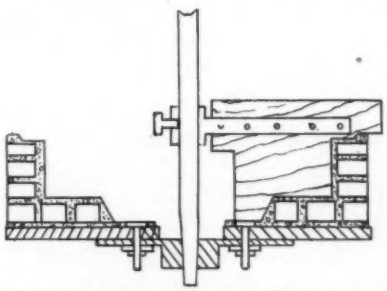


FIG. 4.—SWEEPING MOULD AS ULTIMATELY DECIDED ON.

The method finally adopted demanded two bottom plates, one top plate, a lifting plate or shoe plate, and 12 small core plates. On one bottom plate was fixed a cross and spindle, used to build the bottom and outside of the mould, and also a bearing and guide, the bearing to rest and the guide to set the core in its proper place. (See Fig. 4.) On the second

FIG. 5.—SHOE READY FOR USE.

bottom plate what is called a shoe was built and swept. This shoe might be almost termed a pattern, being built so as to form the bottom and sweep the outside part of the core or inside of the mould, and also to form the part of the guide and bearing swept on the first bottom plate, as shown in Fig. 5. This shoe was made ready for use after building and sweeping to the proper size. (Care had to be taken to see that it was the proper size or it would have caused no end of trouble when closing the mould.) It was well dried and painted when hot with tar, which tarring, as most moulders know, hardens it considerably and keeps out all damp. This shoe, finished and tarred

satisfactorily, and marked off where the brackets should go, was then ready for use. The lifting, or shoe plate, was cast with three 1½-in. round lifting irons, and also with ten ¾-in. staples, one to come opposite the centre between every two brackets to fasten the core plate and lifting or shoe plate together for lifting the outer part of the core or inside of the mould. The core plates were made to fit inside of each two brackets, leaving ¾-in. at least between the casting and the plates, and extending well to the inside of the lifting plate, with a slot cast in each to allow the staples in the lifting plate to go up through to fasten both together. The lifting plate, having been

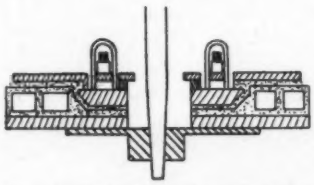


FIG. 6.—SHOE WITH LIFTING PLATE BEDDED ON LOAM, AND CORE PLATE FIXED READY FOR BUILDING CORE.

cleaned and clay-washed, was bedded on a layer of loam ¾ in. thick in the bearing and guide of the shoe, care being taken that the staples in the lifting plate came exactly opposite the centre of each two brackets, which were by this time set at the places marked off for them. After bedding the lifting plate into its place another layer of loam, about the same thickness, or perhaps a little thicker, was then placed on the shoe between the brackets, and the core plates bedded on to it. They were fastened to the lifting plate by the staples mentioned, and by packing pieces and wedges, as shown in Fig. 6. The spindle and board were then fixed, and the core or inside of the mould built and swept up in the usual way, the outer wall with loam bricks and the inner with ordinary bricks. The space between the inner and outer walls

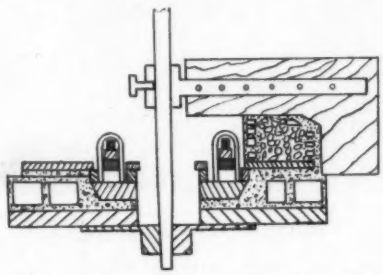


FIG. 7.—BUILDING AND SWEEPING UP CORE; ONE SIDE ONLY COMPLETE.

was filled with ashes for the vent, and a space was left between two bricks on the inner wall to let the vent away. On top of the ashes 1½ in. or 2 in. of loam was placed, strickled off, and completed, as in Fig. 7.

The top plate was made with long and short prods or dabbers to suit the different depths required, the cross-spindle and board were fixed and set, dabbed and swept in the usual way, Fig. 8.

The bottom part or mould, the core or inside of the mould, and the top plate all being built, swept up, and finished, were then stored and thoroughly dried. They were then taken out again, the brackets drawn from the core (those brackets, if made of wood and the edges exposed to the heat, should be protected by covering with loam previous to storing), the core carefully lifted off the shoe, all three parts dressed, blackened, and, if necessary, given a further drying. They were then ready for putting together by lowering the core into its place inside the

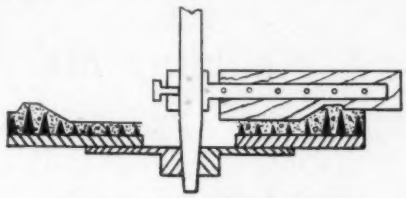


FIG. 8.—TOP PLATE BEING SWEPT.

mould and the top plate on both, Fig. 9. The castings were run from the top down through the top plate, through the ashes and core plates on top of the bottom flange. To protect the gate from breaking into the ashes, round bushes were placed round the gate up through and above the top of the ashes, and

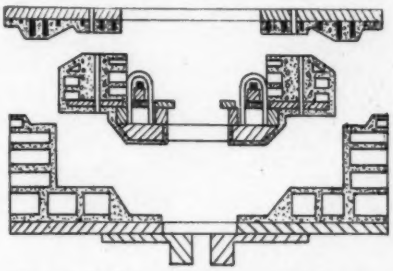


FIG. 9.—MOULD, CORE AND TOP PLATE READY TO BE DROPPED INTO PLACE.

loam was filled between the gate and the bushes. The gate was carried to the top of the core, the gates in the top plate being made to correspond with those in the core. To ensure economy in casting a loam runner was built and daubed upon a runner plate made with holes to correspond with those in the

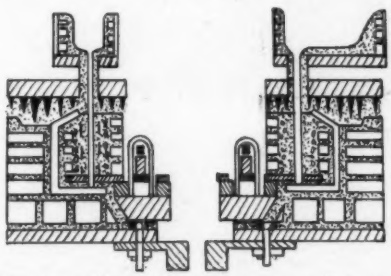


FIG. 10.—MOULD CLOSED, SHOWING RUNNERS AND METHOD OF RUNNING.

mould. Round bushes about 3 in. deep were placed on top round each gate hole in the top plate, the runner was placed and resting on those bushes, each hole in the runner being set to come on top of the bushes. Gate pins being placed in the gate holes in the top plate, and coming up through the bushes and runner, all that was necessary to secure and make this runner complete was a little ordinary green sand facing to ram the bushes up

with. By having risers to run below the level of the bottom of a runner like this, so as to drain all the metal out of it, it could be used many times over by simply lifting it off the mould when cast, brushing it out and blackwashing it again. One advantage of making these castings as described, apart from the economy of moulding them with separate cores as described in the first method, lay in the fact that a uniform thickness was easily got all over, which would be almost impossible the other way. There were no joints between the cores, which saved some dressing and made first-class castings.

A Moulding Machine for Boiler Sections.

Owing to the increasing application of hot water as a heating agent, the question as to the quickest and most economical way of moulding boiler sections is one of great interest. By far the largest portion of this work has up to now been done by hand-moulding, and this was generally considered to be the most practical and the cheapest method to be employed. Recently, however, the London Emery Works Company, Park, Tottenham, London, N., proved that these boiler sections can be produced more economically by hydraulic moulding machines. The reason of many failures that have been experienced in some foundries when adopting hydraulic machinery for pressing the moulds is to be found in the fact that a number of conditions have been more or less neglected, although these are of the greatest importance if success is to be obtained. In the first place it is necessary for the moulding machine to be particularly adapted for the work; then the pattern should be of first-class manufacture, and finally attention should be paid to the preparing of the moulding sand. In many cases the preparation of the moulding sand makes all the difference between failure and success.

In Fig. 1 the hydraulic moulding machine constructed by the London Emery Works Company for dealing with boiler sections is shown. This illustration does not show much of the machine, but gives a splendid view of the turnover plate with the white metal pattern attached to it. A pneumatic vibrator is seen attached to the turnover plate and in the front, resting in the cast-iron trolley, is a casting that has been made on the machine. The size of the moulding boxes for this casting is 5 ft. by 3 ft. 8 in.

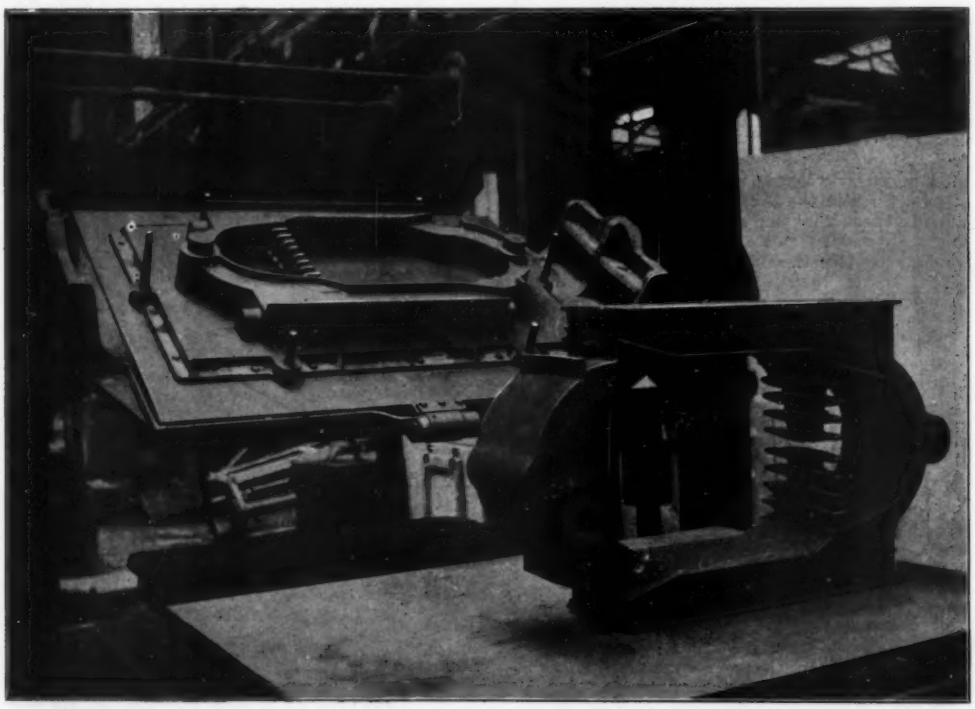


FIG. 1.—SHOWING TURNOVER PLATE WITH PATTERN ATTACHED, AND ALSO A FINISHED CASTING MADE ON THE HYDRAULIC MOULDING MACHINE.

The construction of this turnover hydraulic moulding machine is the same as that described in our issue of May last for making tunnel plates. In both machines hydraulic power is used to ram the moulds and also draw the pattern. The moulds made are perfectly clean, and do not require touching-up or finishing in any way whatever. With regard to the output, it is interesting to know that four men produce about 28 boiler sections a day, including casting and knocking out the boxes.

An Unusual Type of Stripping Plate.

By Thomas Walker.

Fig. 1 represents a ground screw, which is largely used for tennis fittings and tent equipment for soft ground. The length of the casting is 26½ in. long. These castings are ordered in large quantities in the spring of the year, by firms who make a speciality of this class of goods. The writer, having large orders to execute, set about devising the best means for making them in the most economical manner. The screw being of uneven pitch, it is difficult to mould on its side, and jointing, being so irregular, leaves very nasty joint marks the whole length of the thread.

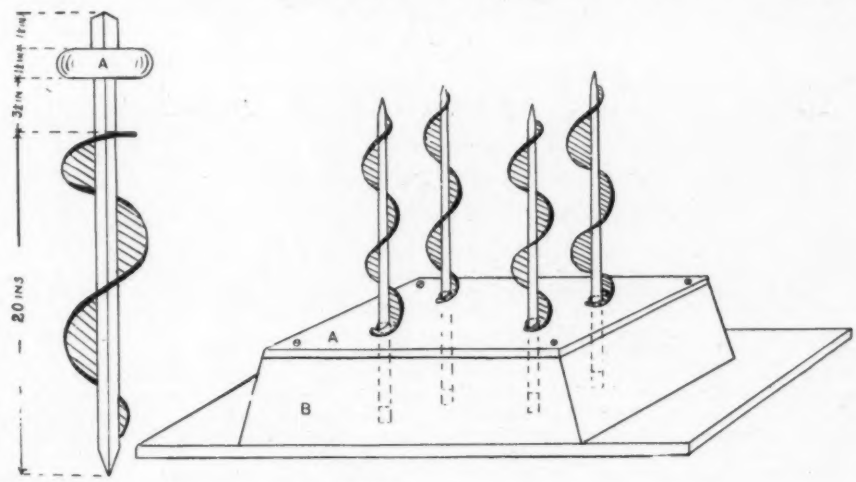


FIG. 1. FIG 2

AN UNUSUAL TYPE OF STRIPPING PLATE.

The pattern was tried in two halves, jointed and dowelled lengthwise, but with no good results. However, the difficulty was overcome by making a stripping plate, as illustrated in Fig. 2. It will be observed that the boss A, Fig. 1, has been turned off so as to admit of pattern being inserted through plate A, Fig. 2, which is made by running a plate of Babbit metal around the screw to form a nut, which is afterwards screwed securely to the frame B, Fig. 2. It will also be noticed that the frame B is provided with a considerable taper, which is explained by the fact that it answers the purpose of a print, as well as an oddside and stripping plate. This is then placed on a board and rammed up in the usual way, care being taken that the whole is very firm. Then the whole is rolled over, and the joint made firm around the print. Patterns are drawn by giving a turn in the required direction. The frame is then drawn and cores, as shown in Fig. 3, are inserted, forming square nut, boss, neck, runner, and also runner peg. Fig. 4 illustrates assembled core, show-

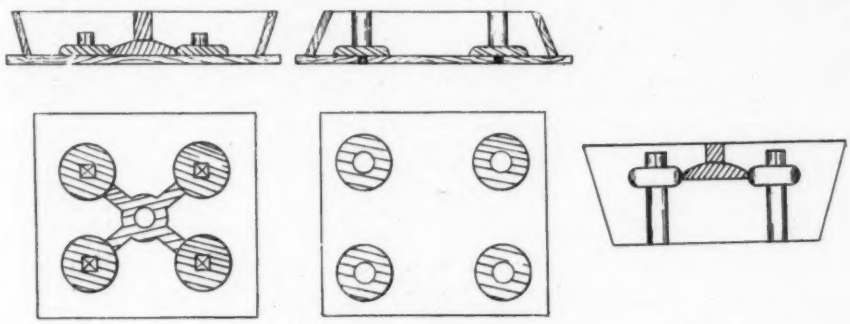


FIG 3. FIG. 4.

AN UNUSUAL TYPE OF STRIPPING PLATE.

ing runner and runner peg. All that is necessary is the ordinary cup placed on top, and the mould is ready for casting. It will be readily seen that the patterns should be in first-class condition, and that they require to be carefully set in the print, so that they come in exact register with the corresponding cores. The writer used a square block of wood, with four holes bored through exactly the diameter of the neck, which protrudes through the stripping plate; this was set out by the pattern-maker, who was responsible for the making of the core-boxes. This simple apparatus proved an unqualified success, and enabled an improver to turn out sixteen first-class castings per hour. This form of stripping plate is not only applicable for single lead screws of a coarse pitch; but the writer has also made four lead screws, ¼ in. pitch, 10 in. long, such as are used on warp dressing machines, with a similar appliance. It may here be added that no great precaution is necessary, such as giving a great amount of space between each screw for fear of bursting and running into each other. A 4 in. space is quite sufficient.

The Wearing Qualities of Semi-steel.*

By J. A. Murphy.

As to whether grey iron containing from 15 to 25 per cent. of steel scrap in the mixture is superior in wearing qualities to common strong machinery grey irons, the writer unhesitatingly answers "Yes," when the steel is properly melted and used in the right proportions for the job in hand, both mixtures being from the cupola.

The term semi-steel is a misnomer, but it has the one redeeming quality that it is meant to express the fact that some percentage of steel was used in the mixture. Semi-steel is no better, if properly made, than an air-furnace iron reduced from cold-blast charcoal iron. On this hinges the whole question. For strength in any form, homogeneity and fine wearing qualities, it is far superior to the ordinary mixture made from all grey iron in either cupola or air-furnace provided it is mixed and melted right and the proper proportions used for the purpose in hand.

For steam, gas, hydraulic and other cylinders it has no superior in strength, rigidity and closeness of grain, homogeneity and durability. Steel becomes such in the first place by the elimination of carbon, principally, and it again returns to cast iron when reduced in the cupola in the presence of fuel, as it again absorbs carbon, just as any other iron does in its original production in the blast furnace.

There is no steel nor any sign of it in semi-steel. The only way it is recognised is by its fracture, the grain being fine, the carbon particles being minute and finely distributed, giving a very close and even fracture in even the thickest sections, being in that respect equal to and mostly superior to good air-furnace iron.

Semi-steel, to use its popular name, has many enemies, principally among those who have failed in its production, and they are legion. Neither all foundries nor all foundrymen can successfully melt steel scrap in the cupola, nor do they know how to mix it for attaining a desired result. It is to these causes, together with a general metallurgical ignorance, that the many failures in the use of steel may be attributed.

"It does not mix," is a common expression. Many cannot keep it from running to holes; others cannot keep it from chilling. Some have experienced such a combination of troubles that they could not be described in a short article, all of which, however, are caused by unscientific mixing, bad melting, and in some cases bad moulding and pouring practice.

I would venture to say that a cylinder cast from this unmixed metal or one in which white spots, streaks or patches show up in the bore or valve seats after being machined, would be unfit for use as it would wear and cut very rapidly. Such spots are not unknown in all grey iron mixtures, for if the metal is not melted right, whether by oxidation, burning or melting at too low a temperature in the cupola, spots and streaks invariably show up on the finished surfaces as white iron.

All engine builders who aim at the highest possible quality use either air-furnace iron or semi-steel in their cylinders. Some even chill the bore, but whether this last method has any advantage over semi-steel or air-furnace iron is a much-debated question; the bore is so close that the lubricating effect of the carbon pits and particles is almost entirely lost.

It is surprising at this stage of advancement in the foundry industry to still find people who ought to know better saying that steel and iron do not mix or make a perfect alloy. When wrought iron or hard steel is used, this is often true, but neither of these is fit for the purpose in the smallest degree, the assertions of some metallurgical authorities on the subject to the contrary notwithstanding. In my own practice I never use wrought iron or hard steel, and I would not advise anyone to do so. They will mix, but the temperature of the cupola can never be relied upon to reduce them properly, and for machine or finished work they are unfit for use.

After a long and varied experience in the engine and heavy jobbing business, I have nothing but the highest regard for steel scrap and the greatest confidence in its efficiency. It closes the grain, reduces the graphitic and total carbon according to the percentage used, and what is more important, through its quicker cooling distributes it more minutely and evenly throughout the section. It prevents sponginess and segregation, lessens liability to cracking, adds to the tensile and transverse strength, increases deflection and modulus of rupture, and gives a high resistance to shock. On the whole, it is so far superior in every way to common grey machinery iron for cylinder work that there is but very little comparison between them.

* "Castings."

The Utilisation of Waste Heat in a Malleable Foundry.*

Ordinarily it would be considered foolish to instal two machines to do work which could easily be accomplished by one, and yet to a certain extent this is what many users of furnaces for metallurgical purposes are doing. The requirements of a melting furnace for a malleable castings plant are such that the products of combustion must leave the furnace at a very high temperature; in fact, above the melting point of cast iron. This means the loss of a large per cent. of the heat units in the coal. The coal must be paid for, and if the owners can realise on the heat units thrown away by the reverberatory furnace, they will secure similar economies to those which have long been practised with rolling mill puddling and heating furnaces.

The Buhl Malleable Company, Detroit, Mich., U.S.A. appreciating the possibility of saving in this direction, installed a waste heat boiler of 250 h.p. capacity for use in connection with one of its malleable furnaces. The boiler is of the vertical water tube type, the fire

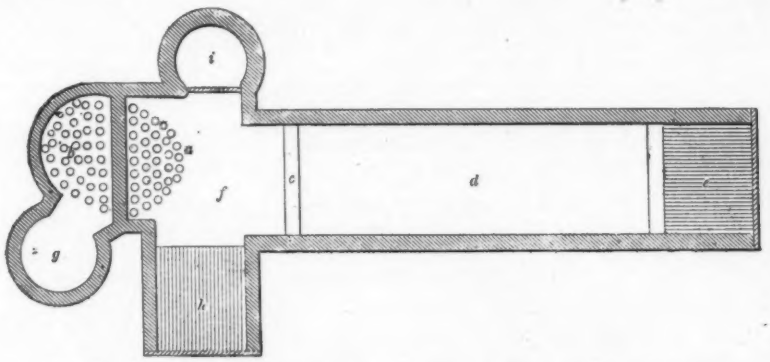


FIG. 1.—DIAGRAM SHOWING ARRANGEMENT OF BOILER AND FURNACE.

ascending on the side *a* and descending on the side *b*, as indicated in Fig. 1. The back bridge wall of the furnace is at *c*, the furnace hearth at *d*, and the furnace firebox at *e*. When the boiler is in use the flame passes from the firebox through the hearth, over the bridge wall to the combustion chamber at *f*,

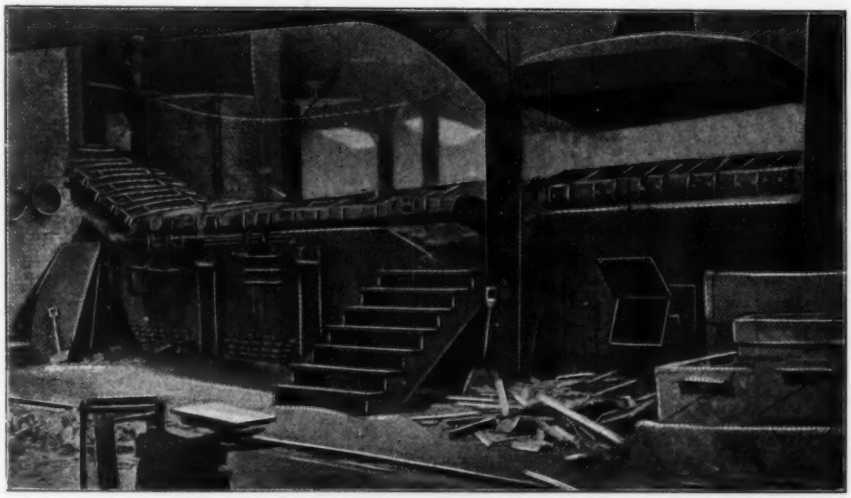


FIG. 2.—VIEW OF REVERBERATORY FURNACE AND EMERGENCY STACK.

which is located between the back bridge wall and the boiler. Thence the flame ascends through the flues on the side *a*, descends on the side *b* and passes to the stack *g*. These conditions are maintained when the furnace is in operation. When it is necessary to shut down the furnace for charging, fire is

* "Iron Age."

started in the auxiliary firebox, located at *h*, and so situated that the flame passes into the combustion chamber *f* through the boiler and up the stack *g*.

If the boiler has to be shut down for repairs or for other reasons, a temporary damper placed at the back of the firebox *f* turns the flame from the malleable furnace into the emergency stack *i*. It would be easily possible to so arrange the flues and the stacks that only one stack would be used, a flue being arranged for a by-pass to take the fire around the boiler; but in the plant under consideration the stack *i* was already in existence, and it was deemed wise to make the boiler equipment entirely independent of the malleable furnace. The top of the furnace is horizontal to a point over the back bridge wall. A series of bungs are arranged on an incline, so that the flame rises toward the boiler. This incline gives a greater height and forms the combustion chamber shown at *f* in Fig. 1.

In the practice at the Buhl Company's plant the fire in the furnace is started at three o'clock in the morning and allowed to burn with natural draft until 6 a.m. At that time the blast is put on and the fireman in charge of the boiler arrives. About 11 a.m. the first heat is tapped. At 11.30 the second heat is charged, and during this operation, in the half-hour from 11.30 to 12, it is necessary to use the auxiliary firebox. The second heat is tapped about four o'clock in the afternoon, and immediately thereafter the furnace is charged for the next morning, so that during the last half-hour of the day it is once more necessary to use the auxiliary firebox. By charging the furnace at night it is only necessary for one man to come at 3 a.m. Whenever the furnace is shut down for repairs a sheet-iron damper is lowered between two of the bungs over the back bridge wall *c*, thus cutting off the furnace from the combustion chamber *f*.

The heat derived from this one melting furnace is sufficient to run the machinery connected with the plant, which includes quite a large machine shop. It is probable that in many operations as now conducted in foundries the melting equipment could be so arranged that much of the waste heat could be used in a way similar to that described above.

Cast-Iron Turning Tools.

The extreme hardness of cast iron when chilled under certain conditions has often been remarked on, but the idea of cast iron turning tools would be regarded by the average founder as a joke. A writer in the "Mechanical World," however, describes an actual cutting tool of cast iron, which he claims, has proven its utility on many occasions.

"I had read in old books," he says, "of such operations as boring cylinders with tools made of cast iron, but had seen no working example nor heard any expressed opinion as to their merits. However, I tried the experiment and found the idea quite practicable. Being made in cast iron, the tool, was, of course, much larger in section than if made of steel. Chilling of the nose of the tool was the method decided on, the following being the system adopted.) Incidentally it may be mentioned that the procedure was suggested by the practice of several textile machinists who chill the noses of the 'tumblers' and 'picking pegs' on looms.) The shank of the tool was about 10 in. long by 2 in. square. The cutting portion was made of the ordinary round nose or 'boot-toe' shape, bottom and side clearance only being provided, no top rake being employed. The shank was not machined to bed on the slide rest, a piece of brown paper laid on the top face of the slide rest being sufficient to insure a rigid grip and absorb vibration. The pattern for the tool was of the shape indicated in Figs. 4 and 5. The oval shape of the tool nose was obtained by a chill, the employment of which explains the presence of the 4-in. cube A on the end of the tool pattern. A pattern of the chill box (Figs. 1, 2, and 3) was made, also the 4-in. cube, which was recessed to the shape of the tool nose, and one or more castings made from it.

"When moulding the cutting tool a mould is made from the pattern Fig. 4, and, the pattern being withdrawn, a chill box is inserted in the corresponding cavity in the mould; the top box is then replaced and the chill box left in the mould while the metal is poured. The molten metal is thus rapidly cooled on entering the chill box and when the casting is removed from the sand the tool nose is practically 'pot-hard.' It is then ground and is ready for use. A decided feature of its characteristics is the ability to cut cast iron which has been chilled through being poured into damp moulds, or is otherwise harder than the normal. The tool has in a number of cases saved partly machined work from being scrapped when good brands of high-speed steel were unequal to the duty under such conditions, the work in question being planing or lathe (surfacing) jobs.

"The depth to which the chill penetrates, and the consequent life of the cutting edge, vary with the cube dimensions of the chill box and the mixture of the cast iron used. When the edge has been ground away, the nose end of the tool can be sawn off and the remainder used as a packing block or remelted.

"It will thus be evident that such tools do not entail unreasonable outlay. At the same time, they are not put forward as a regular substitute for good steel tools, as their bulk renders them rather clumsy to handle while being ground or clamped on the tool rest, but they are useful to have at hand for use on occasional jobs which show themselves unamenable to ordinary methods. Where, however, an amount of plain repetitional surface machining is in question it might—the tools being so cheap—be worth while making comparative tests with the steel and cast-iron tools in order to ascertain which was most suitable, all things considered."

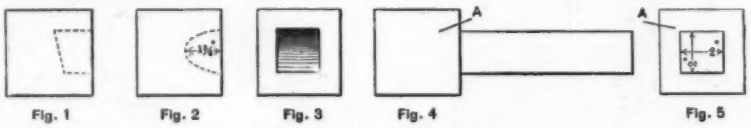


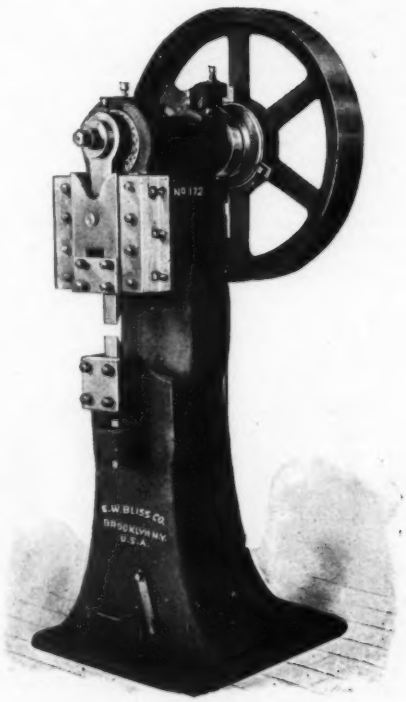
Fig. 1 Fig. 2 Fig. 3 Fig. 4 Fig. 5

A Cast-Iron Turning Tool.

The "Stiles" Power Sprue Cutter.

The illustration herewith shows the "Stiles" power sprue cutter. This machine is especially designed to meet the requirements of brass founders and manufacturers of other soft-metal castings. The operator has both hands free to guide the castings, as the cutters operate in response to a slight pressure on the foot-treadle, stopping automatically at the highest point of the stroke. The frame is so designed as to offer no obstruction, so that long castings, whether set square or at an angle to the main gate, can be cut off as readily and as perfectly as those of smaller dimensions.

The cutters are simply cut off from a bar of tool steel of the requisite section, the cutting part being ground to a bevel edge, which can be done on a grindstone by any labourer. They can be used up



"Stiles" Power Sprue Cutter.

almost to the last inch by setting up the screw adjustments. These adjustments permit of so setting the cutters that they will just cut off the gate without touching each other, thus preserving the keenness of the edges effectually. The cutters can be set as shown in the illustration, or at right angle to that position, as may be desired.

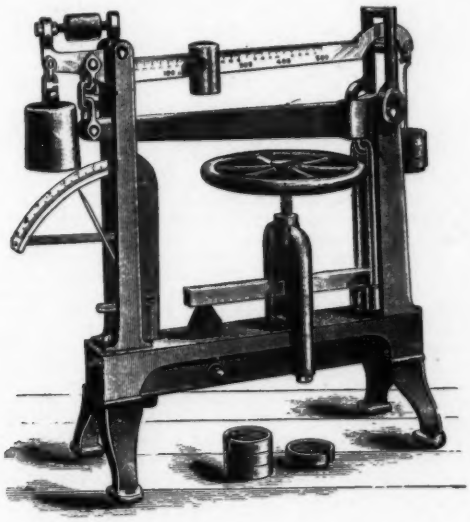
The machine is sometimes located in foundries at such a distance from the driving power, that it is found more convenient to run it by an electric motor attached directly to the machine.

The machine is manufactured in five sizes by Messrs. E. W. Bliss & Company, 114, Queen Victoria Street, E.C.

Transverse Testing Machine.

The machine shown in the accompanying illustration is used in the foundry for testing cast-sample bars. It is made in several sizes, the largest taking bars up to 3 in. square and 5 ft. long. The test bar is first inserted in the machine with either end resting on the lower V blocks, and a strain is applied to it through the upper V block by means of a hand wheel and screw, the strain being counterbalanced or weighed by moving the poise along on the scale beam.

The machine illustrated is furnished with an instrument for indicating the deflection of the sample bar under load, which greatly increases the value of the machine and makes it very useful for ascertaining the strength or quality of cast-iron, inasmuch as the resistance to breaking, as registered on the beam in pounds, multiplied by the deflection in inches and the product divided by twice the weight of the bar in pounds, will give a result which is the



Transverse Testing Machine.

same for the same iron, without reference to the area of the cross section, provided the bar is rectangular and parallel from end to end. The weight of the bar taken is the weight between the V supports.

The results of tests as above indicated vary greatly, being about 10 for worthless iron and 70 for the very best; 20 for the lower grades of foundry products, and 40 to 50 for better class machine castings.

An example of the method of calculating is as follows:—A bar of iron 12 in. long weighs 3 lbs., breaks with a strain indicated on the beam at 2,400 lbs., and deflects one-tenth of an inch; thus we have—2,400 × 1/10 ÷ 6 = 40—which indicates good iron.

These machines are manufactured by Tinius Olsen & Co., for whom Messrs. Edward G. Herbert, Limited, of Rosamond Street, East, Manchester, are sole agents for Great Britain.

Inventions.

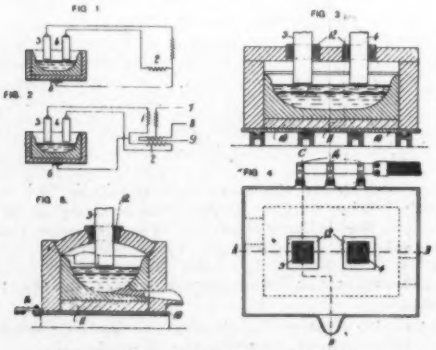
Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

17,342.*Electric furnaces. Aktiebolaget Elektrometall.
17,640. Dehydrating air for metallurgical furnaces. F. W. Harbord.
17,718. Treatment of metals and their alloys. G. Stoker.
17,748.*New metal alloy and process of manufacturing same. A. Jouve.
17,825. Furnaces. J. W. Chenhall, Broad Sanctuary Chambers, London.
17,965. Cutting iron or steel bars by circular saws. S. Marston, 48, Albert Terrace, Middlesbrough.
18,010.*Smoke-consuming furnaces. F. Lindner.
18,451.Process for casting metals and apparatus therefor. W. B. Bary.
18,452. Furnaces. W. B. Bary.
18,610.*Heating, melting, refining, and decomposing metals and other substances. H. Hoff.
18 879. Supporting articles in kilns, muffles, etc., during firing process. W. E. Maddock and C. D. Maddock, Port Hill, Wolstanton, Stoke-on-Trent.

Abstracts of British Patent Specifications recently accepted.

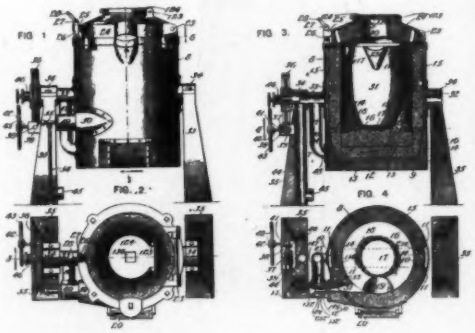
6,088 (1909). *Electric Production of Iron and Steel and other Metals, and Furnaces for Carrying out the same.* Aktiebolaget Elektrometall, 43, Bergsgatan, Stockholm, Sweden.—The invention makes it possible to use two-phase currents without it being necessary to increase the number of adjustable electrodes, beyond that hitherto employed in furnaces for single-phase currents. The invention consists in supplying the furnace with two-phase current in such a way that the terminals of one pole of the two phases are each electrically connected with one of two adjustable electrodes which hang down in the furnace, while the terminals of the other pole of the two phases are electrically connected with the conducting lining of the furnace or else with any other electrode which is in direct contact with the smelting bath. From the two adjustable electrodes the current passes to the smelting bath in the form of electric arcs. Fig. 1 illustrates this connection; Fig. 2



Furnaces for the Electric Production of Iron and Steel.

illustrates in the same way a modified form of the connection. In Fig. 1, 1 and 2 represent the two phases in a two-phase system where the one ends of the phases are electrically connected with each other. The current system is thus interlinked. Each of the two phases is connected with a corresponding electrode 3 or 4 respectively, from which the current passes in the form of electric arcs to the smelting bath where it combines in a current which passes through the conducting lining to the contact 6 and thence again to the source of the current. As the two circuits have a difference of phases of 90 degrees relatively to each other, it is clear that the resultant current which passes through the smelting bath and contact 6 will be $\sqrt{2}$ times greater than the current which passes through each of the electrodes 3, 4, and also that the tension between the two electrodes should be $\sqrt{2}$ times that tension which is consumed in each arc. It is also clear without further explanation that, as nearly the whole of the tension is consumed in the arcs, the current system will be balanced and the two phases equally loaded. If there is a three-phase current it can be transformed to two-phase current by means of the well-known Scott's connection in the transformer belonging to the furnace. The diagram will in that case be as shown in Fig. 2, where 7, 8, and 9 are the three conducting wires from a three-phase system, the other index numbers in this figure indicate the same parts as in Fig. 1. A furnace suitable for the carrying-out of the process in question is shown in vertical section at Fig. 3 taken on the line A—B of Fig. 4, in plan at Fig. 4 and in Fig. 5 in vertical section on the line C—D of Fig. 4.

1,786 (1909). *Crucible Furnaces.* Kroeschell Brothers Company, 55, Erie Street, Chicago, Illinois, U.S.A.—This invention relates to an improvement in the class of crucible furnaces in which the fuel (gas or oil) and the air for promoting its combustion are introduced into the furnace-chamber at or near its base, and the hot gases of combustion are given a gyratory motion in ascending to cause them to envelop the crucible,



Crucible Furnace, by Kroeschell Bros. Company.

supported in the chamber, for heating it to melt its contents. The object of the improvement is to provide features whereby the greatest intensity of heat shall be generated about the lower portion of the crucible to cause its contents to melt from the bottom upwardly, with the advantage of employing the heat of conduction from the lower molten portion of the mass to the upper solid portion thereof to expedite the melting operation, with but slight oxidation of the metals while melting them. Fig. 1 is a view in front elevation of the improved furnace shown as a tilting furnace; Fig. 2 is a top plan view of the same; Fig. 3 is a section on line 3, Fig. 2, and Fig. 4, a section on line 4, Fig. 3.

Trade Talk.

THE address of the Swedish Chamber of Commerce in London, has been changed to 5, Lloyd's Avenue, E.C.

THE SHEFFIELD HACKSAW COMPANY, of 61, Norfolk Street, Sheffield, have removed to the London Works, Bridge Street, Sheffield.

MESSRS. A. J. BAXTER and D. CALLANDER, engineers, etc., Sidney Street, London, E.C., trading under the style of Baxter & Callander, have dissolved partnership.

J. BEARDSHAW & SONS, LIMITED, of the Baltic Steel Works, Sheffield, have been elected members of the British Chamber of Commerce in Paris.

MESSRS. R. MILLER and S. FAIRBROTHER, blacksmiths and engineers, Hyde, Cheshire, trading under the style of Joseph Cooper & Company, have dissolved partnership.

AN outbreak of fire occurred at the Hydepark Works, of the North British Locomotive Company, Limited, on August 13, but the damages were not heavy, being confined to a store.

A DISSOLUTION of partnership is notified in connection with Messrs. M. H. Liptrot and G. H. Chadbond, file manufacturers, Bolton, who traded under the style of Liptrot & Chadbond.

MR. J. M. MONCRIEFF, has removed his offices from Consett Chambers, Pilgrim Street, to Pearl Buildings, Northumberland Street, Newcastle-on-Tyne.

I. FRANKENBURG & SONS, LIMITED, of the Greengate Rubber and Cable Works, Salford, Manchester, have appointed Messrs. Watson & Whyte, 19, Waterloo Street, Glasgow, as their agents in Scotland.

AMBROSE SHARDLOW & COMPANY, LIMITED, of the Ealing Engineering Works, Washford Road, Attercliffe, Sheffield, are installing a new heating and annealing furnace of the Kirkham improved type.

MESSRS. R. A. BRADSHAW & SON, of the Carr Foundry, Retford, Notts., have secured a large order for standard poles, and bases, from the Tramway Department of the London County Council.

MESSRS. DAVIDSON & BLACKADDER, of 50, Wellington Street, Glasgow, have been appointed agents for the St. Helens Cable and Rubber Company, Limited, of Warrington, for the whole of Scotland.

THE VICTORIA FOUNDRY, Batley, the property of J. Bagshaw & Sons, Limited, is to be offered for sale as a going concern, and in the event of no satisfactory disposal of the business being effected the works will be closed.

THE MIDLAND RAILWAY CARRIAGE AND WAGON COMPANY, LIMITED, who some time ago decided on the erection of new works, have now let the first contract in connection therewith, and the work is being proceeded with.

A DISSOLUTION of partnership is notified in connection with Messrs. R. Owen, D. W. Prosser, W. John, and D. W. James, mechanical engineers, etc, Neath, Glam., who traded under the style of the Dynevor Engineering Company, so far as regards Mr. D. W. James.

MR. J. LAMBIE and Mr. C. R. Wrigley have acquired the London contracting business of the Walsall Electrical Company, Limited, at 116, City Road, E.C. Messrs. Lambie and Wrigley will also represent the Walsall Company for their various manufactures.

THE BRECON AND MERTHYR TYDVIL JUNCTION RAILWAY have placed an order with Robert Stephenson & Company, Limited, for the supply of four locomotive engines. They will be of the 8-wheel type, 6-wheel coupled, and of a more powerful type than any hitherto used on the Brecon and Merthyr system.

T. C. AVELING & COMPANY, LIMITED, engineers, Meriden Street, Birmingham, are building new repair shops and offices on land leased from the London and North-Western Railway Company, in New Canal Street, Birmingham. When these new works are completed, the Meriden Street business will be transferred to them.

MR. A. W. BLAKE, A.M.I.Mech.E., A.M.I.E.E,, has severed his connection with Mills, English & Company, Limited, consulting engineers, patentees, and buying agents, 4, Castle Square, Swansea, with whom he has been associated for the past three years, and has taken offices at 66, Wind Street, Swansea, where he intends to practice as a consulting engineer.

MESSRS. ESCHER, WYSS & COMPANY, manufacturers of turbines, pumps, etc., inform us that the arrangement with Mr. Jens Orten Böving, who formerly represented them in Great Britain, terminated on May 1 last, and that all enquiries intended for the firm should be addressed to their new London office at 109, Victoria Street, Westminster, London, S.W.

MR. A. CARTLEDGE, steel, tinplate, and metal agent, of Sheffield House, 5, Laurence Pountney Hill, London, E.C., informs us that he has been appointed sole British agent for the following firms:—E. Vosseloh, manufacturer of steel springs washers, clips, forgings, etc., Werdohl, Westphalia; Lohmann & Soeding, manufacturers of steel shovels, spades, etc. Witten, Westphalia; and D. Möhling & Company, manufacturers of steel rivets, bolts, chains, etc., Dahle, Westphalia.

MR. F. S. MILNE, who some time ago left the Newcastle-upon-Tyne Electric Supply Company, Limited, to take up an appointment in the Argentine in connection with the Electrical Department of the State Railways, has commenced business in Buenos Ayres as commercial engineer and agent for British railway, mechanical, and electrical engineering firms. Associated with him as British engineer and secretary is Mr. J. A. Seager, A.M.I.C.E., A.I.E.E., of Emerson Chambers, Newcastle-on-Tyne.

A DEMONSTRATION was given recently, in Newcastle, of the efficiency of a patent smoke-abater and evaporator which has been specially designed by the Eldon Engineering Company, in Newcastle-on-Tyne. The smoke, as it passes through the apparatus, is dealt with by a system of sprays. The furnace was charged with inferior coal, which emitted a black smoke. No sooner, however, was the water pumped through the various compartments of the smoke-box than the smoke gradually disappeared.

A DEMONSTRATION was recently given by Mr. Martin Kallman, president of the Oriental Trust Company, of Paris and London, at his laboratory in South London, of a process he is developing for turning iron bars into steel. Among those who witnessed the demonstration were several engineers and steel makers, representing British firms. The details of the process are not available, but it is stated that by coating iron with a certain preparation and heating in an air-tight retort, it is transformed into high-grade steel; or a coating only of steel may be formed. It is suggested that Messrs. Vickers, Sons & Maxim, Limited, have made overtures to Mr. Kallman for the exclusive British rights, but this lacks confirmation.

ENGINEERING Day at the Imperial International Exhibition at the White City, Shepherd's Bush, which has been organised by the General Mechanical Engineering Committee, the Mining and Metallurgical Committees, and the Building and Engineering Construction Committee, has been fixed for September 4. Visits will be paid to various exhibits of interest, and during the afternoon the following papers will be read:—"Snap-Shot Drawing for Engineers and Architects," by T. R. Ablett; "The Simplest Perspective Drawing of Machinery," by C. Anthony Ablett; "The Extended Uses of Electricity on Board Ship," by J. McLaren; "The Treatment of Boilers for Long Voyage Ships," by H. Rock Keen; and a lecture on gas engines, by Mr. P. R. Allen.

IN giving evidence before the Consultative Committee on Attendance at Combination Schools, Mr. J. R. Richmond, who is manager of the extensive business of G. & J. Weir, Limited, and who spoke on behalf of the North-Western Engineering Trades Employers' Association, remarked that he could not say whether boys of to-day were less intelligent than those of past generations, but he had noticed a very marked

superiority of country boys over town boys in respect of their powers of observation and their intelligence. He thought that this was partly due to the conditions of country life being more favourable to the development of habits of observation, and partly to the fact that country schoolmasters had greater opportunities of coming into close contact with their pupils and with their home circumstances, and consequently took greater interest in them. He also thought it possible that the larger classes in town schools tended to routine instruction instead of real education.

A SMART piece of work was carried out recently by employés of the Knowles Oxygen Company, Limited, Walsall Street, Wolverhampton, at J. H. Pearson's Netherton Furnaces, Netherton. Owing to an accident the crank shaft of one of the large vertical blowing engines had broken, and amongst other damage, the piston-rod had been bent in such a manner that it seemed impossible to remove it from the cylinder. The Knowles Oxygen Company, however, by means of an oxyhydrogen cutting blow-pipe, cut off the piston-rod, which was about 7 in. in diameter, close to the gland of the cylinder. The work was one of particular difficulty, because the cut had to be made overhead, close under the large cylinder cover, and at a considerable height from the ground. In spite of this, and that it was the first attempt of the kind the men had made, the work only occupied 35 minutes from start to finish.

THE correct declaration of machinery imported into France seems to be a somewhat difficult matter, for the British Chamber of Commerce, in Paris, have lately received numerous representations from British machinery manufacturers complaining of the difficulty which they experience in obtaining from the French Customs tariff the information necessary to enable them to correctly declare their goods on import into France. In several cases the importers have declared machinery according to a classification of the French Customs tariff which appeared to them to apply fairly to the goods: they have, however, subsequently been informed that their declaration was wrong and have been fined. It appears that it is not safe to base declaration, especially of articles so complicated as machinery, upon a simple description contained in the French Customs tariff. It is usually necessary to carefully examine the explanatory notes of the Customs before a correct declaration can be made, and the Chamber strongly urges British engineers, in their own interests, to obtain a definite classification before making shipment. The Chamber constantly supplies the necessary particulars to members upon receipt of blue print or plan of machinery.

THE voting on the question of certain suggested reforms in the work of the Institution of Civil Engineers, which a committee has been considering for some time past, has now been made known by Mr. A. S. E. Ackermann, the hon. sec. of the committee. Regarding the question of re-organisation in the constitution of the governing body of the Institution (such as the establishment of sub-committees, and all classes of members being represented on the Council), there was a large majority in favour. As to there being regulations for professional conduct and a scale of minimum remuneration, 2,085 votes were given, of which 81 per cent. were in the affirmative. For the Institution entering more prominently into research work, 65 per cent. were in favour, and 86 per cent. agreed on the question of a system of assisting members and students to obtain appointments. Out of 2,063 voters, 72 per cent. thought greater prominence should be given to practical experience in the present system of examinations. These figures were submitted to the Council of the Institution, and resulted in one or two improvements being carried out by that body. The Council have drawn up a brief code of etiquette, and have submitted the code to the vote of the members, with a view to it being incorporated in the by-laws. They also issued a report, in pamphlet form, on the whole of the matters to be dealt with at the annual general meeting, and this report was sent out a week in advance of the meeting.

New Companies.

COLD DRAWN STEEL COMPANY, LIMITED.—Capital £2,500 in £1 shares, to carry on the business of manufacturers, rollers, tilters, and forgers of iron, steel, and other metals, etc.

WINTERINGHAM, LIMITED.—Capital £5,000 in £1 shares, to adopt an agreement with G. Winteringham, engineer, of Northampton, and to carry on the business of engineers, etc.

GEARY, ADAMS & COMPANY, LIMITED.—Capital, £3,000 in £1 shares, to adopt an agreement with F. C. Geary, and to carry on the business of electrical installation and general engineers and agents, etc.

SMOKE DESTROYER COMPANY, LIMITED.—Capital £500 in £1 shares, to acquire, deal with, and turn to account certain patents for inventions relating to smoke-destroying devices for steam boiler or other furnaces, etc.

MURRAY, WORKMAN & COMPANY, LIMITED.—Capital £12,000 in £1 shares, to adopt an agreement with Angus Murray & Sons, engineers, Craigton Engineering Works. Registered office: Craigton Engineering Works, Craigton, Glasgow.

BALMFORTH BROTHERS & COMPANY, LIMITED.—Capital £2,000 in £1 shares, to take over the business carried on at Peel Ings Foundry, Rodley, Yorkshire, by the receivers for the debenture holders of Balmforth Brothers, Limited.

WHITFORD STEEL SHEET AND GALVANISING COMPANY, LIMITED.—Capital £80,000 in £10 shares, to acquire and turn to account steel, iron, coal, charcoal, and other works, and in particular certain land and hereditaments at Baglan, Glamorganshire.

ISAAC NASH & SONS, LIMITED.—Capital £35,000 in £1 shares (25,000 preference), to carry on the business of anvil and vice makers, etc., and to acquire the business carried on at Wollaston, near Stourbridge, Worcestershire, as Isaac Nash & Sons.

JAMES MCCROSSAN, LIMITED.—Capital £1,000 in £1 shares, to take over the business of an iron and brass-founder and moulder, formerly carried on by the late J. McCrossan at Edgar Street, Liverpool. Registered office: Edgar Street, Liverpool.

SIMPLON MANUFACTURING COMPANY, LIMITED.—Capital £5,000 in £1 shares, to carry on the business of manufacturers of mathematical instruments in brass, celluloid, and other metals and substances, etc. Registered office: 17, Lonsdale Street, Carlisle.

NOAH BLOOMER & SONS, LIMITED.—Capital £8,000 in £1 shares, to take over the business of chain and anchor manufacturers carried on by J. D. Bloomer, E. Bloomer, N. E. Bloomer, and S. J. Bloomer, at Oak Works and Church Street Works, Quarry Bank, Staffordshire.

FERRYBRIDGE FOUNDRY COMPANY, LIMITED.—Capital £10,000 in £1 shares (5,000 preference), to take over the business carried on at Ferrybridge and elsewhere by H. M. Ashley as the Ferrybridge Foundry Company. Registered office: The Foundry, Ferrybridge, Yorkshire.

MODEL ENGINEERING COMPANY, LIMITED.—Capital £2,500 in £1 shares, to take over the business of a model and general engineer carried on by R. M. Wright as the Model Manufacturing Company. Registered office: 52, Addison Road North, Holland Park, W.

J. B. BRUCE, LIMITED.—Capital £35,000 in £10 shares, to take over the business of a brassfounder carried on by J. B. Bruce at Havelock Works, Holloway Head, Birmingham, as J. B. Bruce, and the business of a brassfounder carried on by him at 60, Burbury Street, Birmingham, as Price & Tunnicliff.

BROOKES, WARD & COMPANY, LIMITED.—Capital £6,000 in £1 shares, to take over the business of art metal manufacturers, stampers, and piercers, carried on at 5 & 6, Hampton Street, Birmingham, as Brookes, Ward & Company, and to adopt an agreement with W. H. Brookes and J. Brookes.

ALFRED WISEMAN, LIMITED.—Capital £15,000 in £1 shares, to take over the business of an iron and general metal founder, engineer, etc., carried on by A. Wiseman at Venus Works and Globe Works, Glover Street, Birmingham, as Alfred Wiseman, the Electric Tramway Equipment Company, S. C. Parkes & Company, and F. and J. Allen.

JOHN NEEDHAM & SONS, LIMITED.—Capital £2,000 in £1 shares, to take over the business of iron and brass founders and finishers carried on by John Needham & Sons, at Millgate Foundry, Millgate, Stockport, Cheshire, and to adopt an agreement with O. Needham, J. W. Needham, and W. Needham. Registered office: Millgate, Stockport.

HILL & SMITH, LIMITED.—Capital £50,000 in £1 shares, to adopt an agreement with E. M. Smith for the acquisition of the business of a manufacturer of iron and wire fencing, gates, railings, etc., carried on at Brierley Hill Iron Works, Worcestershire, London, and elsewhere, as Hill & Smith. Registered office: Brierley Hill Iron Works, 18, Canal Street, Harts Hill, Worcestershire.

BUTE DOCKS SUPPLY COMPANY, LIMITED.—Capital £100,000 in £1 shares (80,000 6 per cent. cumulative preference), to take over the business of wagon builders, repairers, and financiers, and steel manufacturers and merchants, etc., carried on by G. Lewis, H. G. Lewis, J. L. Lewis, and P. G. Lewis, at Cardiff and elsewhere, as the Bute Docks Supply Company. Registered office: 1, Pearson Place, Bute Docks, Cardiff.

ARCHIBALD EDMESTON & SONS, LIMITED.—Capital £35,000 in £1 shares (17,500 pref.), to acquire the business carried on by C. Edmeston & A. Edmeston at Patricroft, Lancs., as Archibald Edmeston & Sons, and to carry on the business of engineers, manufacturers of machinery, etc. Registered office: Springfield Engineering Works, Cawdor Street, Patricroft, near Manchester.

WORKINGTON IRON AND STEEL COMPANY, LIMITED.—Capital £2,000,000 in £1 shares, to take over the undertakings, businesses, properties, and assets of the Workington Iron Company, Limited, the Harrington Iron and Coal Company, Limited, the Moss Bay Hematite Iron and Steel Company, Limited, and to acquire all or any part of the properties of Cammell, Laird & Company, Limited, situate in Cumberland, to adopt agreements with the said companies and the liquidators of the said first three companies, and to carry on the business of ironmasters and founders, smelters, iron ore proprietors, steel makers, colliery owners, coke manufacturers, etc. Minimum cash subscription, seven shares. First directors (not less than six or more than 15): Sir John S. Randles, Kt., M.P., J. Ellis, W. Burnyeat, H. E. Wilson, A. H. Mallalieu, W. J. D. Burnyeat, M.P., G. G. Glen, H. Valentine, F. Mallalieu, W. Ellis, R. E. Highton, H. Mallalieu, H. Westlake, and Major A. Handley. W. Burnyeat, J. Ellis, R. E. Highton, and H. E. Wilson are the first managing directors, with £1,500 per annum as remuneration.

Limited Partnership.

T. CLEMMONS & COMPANY.—Registered August 6. Aluminium Casters, Lozells Road, Handsworth, Staffordshire. Partnership for ten years from April 14, 1909. General partner: T. Clemmons, 20, Ivy Road, Handsworth. Limited partner: J. Littlehales, High Street, Erdington, contributing £300 in cash.

New Catalogue.

ALEX. TURNBULL & COMPANY, LIMITED Bishopbriggs, Glasgow. We have received from this firm a coloured wall-sheet of their "Excelsior" patent full bore parallel slide valve, which contains several very special features, which we believe are not found in any other parallel slide valve on the market.

Legal.

Trade Union Law.

At Tower Bridge Police Court, recently, an unusual application was made to Mr. Rose by a member of the Friendly Society of Ironfounders. He said that he had been out of employment for a long period, and was travelling from town to town seeking work. Under the rules he was still entitled to receive 5s. a week out-of-work pay, less 1s., his contribution to the Society, and 6d. per night for his bed. The Executive Council, however, had stopped these benefits, and had sent him a new membership card, on which they had charged him with a debt of £1 16s. 3d. Of that sum £1 was a fine for the alleged alteration of a cheque by him. That he absolutely disputed, and he wished a summons to compel the Society to continue the benefits to him.

Mr. Rose pointed out that although it was called a Friendly Society, it was registered as a Trade Union, and therefore a magistrate had no power to decide disputes.

Applicant: Supposing they fling me out, as they have almost done, cannot I appeal to the law?

Mr. Rose: It was thought best for the benefit of working men to exclude the jurisdiction of the courts to interfere in disputes between members and Trade Unions. With a Trade Union I have absolutely no power at all. You surely have some appeal under the rules?

Applicant: I have appealed right through, and this card is the last result from the Executive Council. The card is no use to me. Have I no redress in the law courts?

Mr. Rose: On the contrary, you are shut out. They have said that Trade Union disputes shall not be dealt with by any court of law.

Applicant: If they should be owing me some money, is there not some court where I could sue them?

Mr. Rose: No.

Applicant: It is rather curious that the law should allow them to carry on their business in this way, under a cloak.

Mr. Rose: If you ask me, I too think it is; but, you see, they have their Act of Parliament.

MESSRS. M. A. TEMPEST and F. W. NICHOLLS, brassfounders, Birmingham, trading under the style of James Gibson, have dissolved partnership.

MESSRS. A. CLERK and E. S. NOKES, mechanical engineers, Leicester, trading under the style of Clerk & Nokes, have dissolved partnership.

MESSRS. W. B. SMITH and J. FRASER, engineers and steel founders, Glasgow, trading under the style of Clydesdale Steel and Foundry Company, have dissolved partnership, so far as regards Mr. J. Fraser.

A MEETING of the creditors of Sir Theodore Fry & Company, Limited, was held at Darlington, recently. The meeting was private, but it was understood that the appointment of Mr. W. B. Peat as liquidator was confirmed, and the meeting appointed a consultative committee of five, representing the principal creditors, to act with him.

AT the Wolverhampton Bankruptcy Court, recently, the public examination in bankruptcy was resumed of Thomas Pedley, formerly carrying on business as a brass and iron founder at Level Lane Foundry, Walsall Street, and the Midland Foundry, Lichfield Street, Willenhall. The statement of affairs showed gross liabilities amounting to £14,713, of which £10,143 was estimated to rank for dividend, and the estimated deficiency was £7,948. Upon the application of the Official Receiver, the Registrar ordered the debtor to furnish an amended deficiency account, a trading account from November, 1907, and an account of the moneys paid into and drawn from the banking account of the debtor's wife. The examination was adjourned until September 29.

Replies.

Moulding Sash Weights by Hand.

In the June number of the FOUNDRY TRADE JOURNAL we noticed a reader asking for a quick method of moulding sash-weights by hand. Perhaps the method adopted by our firm, which we found to be very successful, may be of interest. We made them on the "plate" style, but since an iron pattern would have been much too heavy for hand work, we got two pieces of Cypress, 3 ft. 6 in. by 18 in. by 1¼ in., and joined them together in the centre with wooden dowels. Then we put the board through the planing machine and made it straight and true. Two iron straps, 2½ in. by 1¼ in., were then sunk into the face of the boards, slanting them across and thereafter fixed thoroughly with screw nails. Straps, 1¼ in. broad, were also put across each end, and at each corner was fixed a short piece about 8 in. long, for rapping purposes. We then got pattterns made in

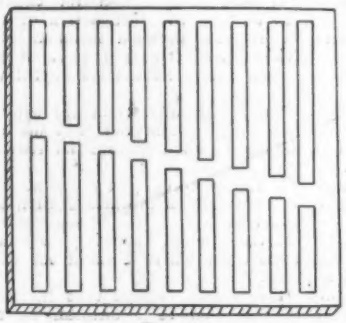


FIG. 1.

halves (vertical) with holes and dowels. The dowels were made long enough to go through the board and both halves of patterns; by this means a perfect fit was assured. The patterns, ranging from 5 lbs. to 15 lbs., were fixed on each end, and arranged as shown in Fig. 1. A runner was also put across for gates. The time taken may be of further interest. We started two men to make the weights at first, and they took, in all, ten minutes to make the complete box—total weight 2 cwts. Latterly we put on a young lad, about 17, who had no previous knowledge of the trade, and in a very short time he was able to turn them out in 40 minutes. Taking this with a day, of, say, 8 hours, he would make 24 cwts. at a cost of about 1½d. per cwt. for the making. This would be difficult to beat. We may say, for the benefit of patternmakers, should any think it worth their while to try our plan, that in the top part of the pattern the hollow for the knot of the cord was

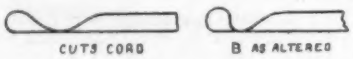


FIG. 2.

made in such a shape as not to make too sharp an edge where all the weight would be on the rope. We had to make an alteration on our patterns at this part as the weights were cutting the supporting cords close at the knot. We shaped them as shown at B in Fig. 2. On the under or drag half a slot was cut right through so as to make sure that the weight would hang vertically when fixed to the rope. Readers must have often noticed that sash weights have a tendency to incline from the perpendicular, thus causing friction in the raising and lowering of the windows. Boxes were made to suit our board, and in order that they might be as light as possible, V-shaped cross-bars were cut in top half to suit patterns. A good coat of varnish is, of course, essential. Our board has been in constant use for about four years now, and is as good as when new.

"A. M. H."

Heat-Resisting Cast-Iron Pans.

I presume it is merely heat alone that is causing the trouble. If the acids come in contact with the iron, special iron is used, according to the class of acid being treated. With regard to heat alone, the way to overcome the trouble is to get a mixture with as low a phosphorus content as possible, the phosphorus causing a fusible phosphide-of-iron. Grey iron is preferable in this case. To further reduce the phosphor content scrap steel may be added to the ladle, to the amount of 5 per cent. This causes a reduction in the temperature of the metal, and in order to get back the temperature, 2½ lbs. of thermit to the ton of molten metal should be added. A mixture of 75 per cent. hematite and 25 per cent. good scrap should meet your requirements.

"J. P."

Deaths.

MR. T. BELLMAN, for a number of years manager of the Backbarrow Iron Works, Ulverston, died recently, aged 73 years.

MR. JOSEPH W. THOMPSON, Salem, Ohio, U.S.A., died on July 15, aged 76 years. He had been associated with the Buckeye Engine Company practically all his business life, and was the inventor of many feature of the Buckeye engine, particularly the valve mechanism and the automatic governor. He was also the inventor of the American-Thompson steam engine indicator.

MR. T. TURNER, managing director of the well-known engineering firm of Andrew Barclay, Son & Company, Limited, Caledonia Works, Kilmarnock, died at his residence, Grange Terrace, on August 7. His health had not been satisfactory for some time back, but he had only been confined to the house for a fortnight. A native of Blaydon-on-Tyne, Mr. Turner, after gaining engineering experience both at home and abroad, went to Barclay's when the firm was formed into a limited liability company some 14 years ago, and under his able management the works were largely reconstructed and very considerably extended, the number of employés at present being about 600. Mr. Turner had a wide knowledge of engineering in all its branches and was an excellent organiser. He took a prominent part in the affairs of the Mining Institute of Scotland and of the Engineering Employers' Federation, in both of which he had held office.

MR. F. T. RUNDALL, Lancashire and Cheshire agent for the Caledonian Tube Company, Coatbridge, has been appointed agent for the same districts for Monks, Hall & Company, Limited.

MESSRS. W. DICKIE & SONS, of the Victoria Implement Works, East Kilbryde, Lanarkshire, have acquired the engineering business of Mr. W. McNaughton, of Forth Street, Stirling, N.B.

THE late Mr. Thomas Johnston, J.P., general manager of Nobel's Explosives Company, Limited, of Glasgow, and a director of the Birmingham Metal and Munitions Company, Limited, left personal estate of the total value of £49,667.

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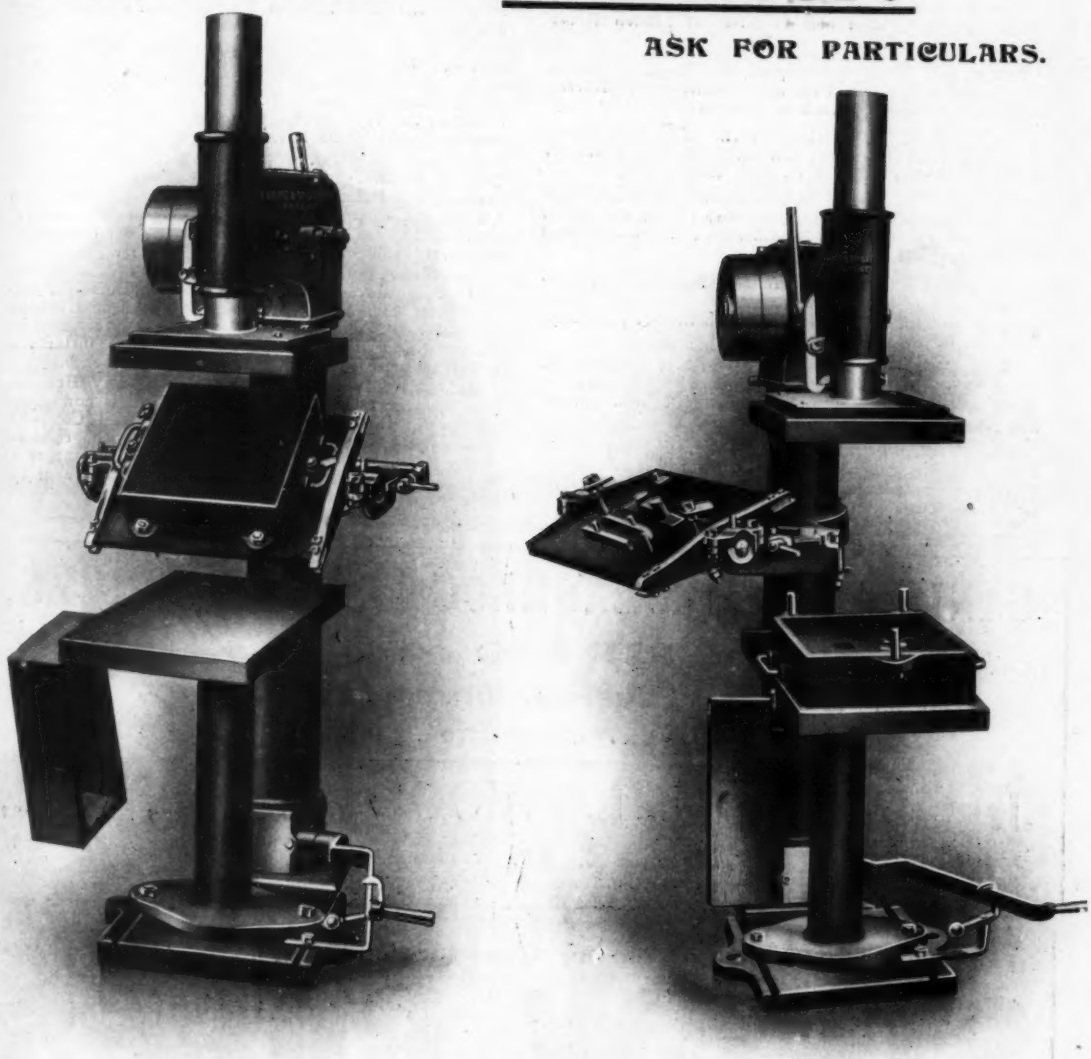
OF EVERY DESCRIPTION.

The New "Puncher."

ASK FOR PARTICULARS.



EVERYTHING FOR YOUR FOUNDRY.

JAMES EVANS & CO.,
Britannia Works, BLACKFRIARS, MANCHESTER.

Personal.

MR. H. H. POTTS has been elected a director of John Henry Andrew & Company, Limited, Toledo Steel Works, Sheffield.

MR. C. A. HUNTON, has been elected a director of Moses Eadon & Sons, Limited, President Works, Savile Street E., Sheffield.

MR. E. J. CHAMBERS has been elected chairman and managing director of the Electro-Mechanical Brake Company, West Bromwich.

THE gross value of the estate left by the late Mr. Walter Spencer, steel manufacturer, of Linden House, Morgate, Rotherham, is £12,759.

THE late Mr. F. N. Thompson, of Benjamin Walters & Company, Limited, lock manufacturers, of Wolverhampton, left estate valued at £19,806 gross.

MR. A. CAMPION, secretary of the West of Scotland Iron and Steel Institute, will on September 1 remove to the Technical College, George Street, Glasgow.

THE late Mr. George Edwin Drury, of Scunthorpe and Bridlington, late managing director of the Trent Iron Company, Limited, Scunthorpe, left estate valued at £8,491 gross.

THE gross value of the estate of the late Mr. John Thompson, engineer and boiler manufacturer, of Wolverhampton, is £43,491 11s. 3d., of which the net personalty has been sworn at £41,837 11s. 7d.

THE late Major Joseph Henry Smith, of Summerhill Court, Kingswinford, Staffs., principal of the firm of Messrs. Hill & Smith, of Brierley Hill Iron Works, left estate valued at £70,092 gross.

MR. P. W. FAWCETT, chief engineer of Thos. Firth & Sons, Limited, Sheffield, Mr. Edward Dixon, a departmental manager, and Mr. Frederick Best, the secretary, have been elected directors of the company.

ENGINEER REAR-ADMIRAL J. T. CORNER, manager of the engineering department at Portsmouth Dockyard, retired on August 16, after 44 years' service in the navy and 28 years' connection with the Portsmouth establishment.

MR. J. M. WHILE, director and general manager of the Barrow Hematite Steel Company, Limited, has retired from the management of the iron and steel works at Barrow. Mr. While will, however, continue to act on the Board as a director of the company.

THE late Mr. Henry Webb, of Joseph Webb & Sons, Limited, Irwell Forge and Rolling Mills, Bury, and a director of Brooks & Doxey, Limited, and the Johnson Landell Electric Traction Company, Limited, left estate of the gross value of £22,200, with net personalty £21,935.

COLONEL F. SHUTTLEWORTH has been elected chairman of Clayton & Shuttleworth, Limited, in the place of Mr. F. S. E. Drury, and Messrs. A. Shuttleworth, G. H. Shipley, and A. C. Newsum have joined the board in the room of Messrs. Drury, H. F. L. Orcutt, and S. Sparkes, who have resigned.

THE late Mr. Andrew Simpson McClelland, of Glasgow, a director of the Steel Company of Scotland, Limited, the Dalmellington Iron Company, Limited, and the Dayton Coal and Iron Company, Limited, left, in addition to considerable real estate, personal estate of the total value of £51,481.

THE CUTLERS' COMPANY, of Hallamshire, at a meeting held on Tuesday, in the Cutlers' Hall, Sheffield, decided to appoint Mr. Herbert Barber, of the firm of Daniel Doncaster & Sons, Limited, steel manufacturers, as Master Cutler for the ensuing year. The installation will take place in the Courthouse on October 5.

MR. J. WILEY, secretary of the Moss Bay Hematite Iron and Steel Company, Limited, which is now incorporated in the Workington Iron and Steel Company, Limited, has been appointed secretary of the combination. Mr. George Valentine, blast-furnace manager at Moss Bay, has been appointed to take charge of the metallurgical department.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

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ESTIMATES FOR WORK AND ILLUSTRATED PAMPHLET upon application to

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ELDERS FOUNDRY COKE

AS SUPPLIED TO THE BRITISH ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From MOUNTFORD PHILLIPS & CO., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, Ltd., Cardiff.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

Metals.	End Aug., 1909.	End Aug., 1908.
Iron—Scotch pig warrants ton	*57/3	*56/6
—Middlesbro' warrants ton	51 4½	51 9
—W.C. Mnos Bessemer ... ton	60 6	58/0
—Stock, Scotch ... ... tons	1,000	1,000
Copper—Chili bars, GMB ton	£59 8 9	£60 10/0
—Stock, Europe and afloat tons	†80,852	44,785
Tin—English ingots ... ton	£137 10/0	£133 2/6
—Straits ... ... ton	£138 2 6	£133 7/6
—Stock, London, Holland, U.S.A., and afloat ...tons	†20,523	16,304
Lead—English pig ... ton	£12 17 6	£13 16/3
Spelter—Ord. Silesian ... ton	£22 0 0	£19 5 0
Quicksilver (75lb)... bottle	£8 5 0	£8 2/6
Antimony—Regulus ... ton	£29 10/0–£30 10/0	£31 0/0 £32 0/0

* Settlement price. † Aug. 16th. ‡ June 30th.

Castings.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	6 10 0	to	6 15 0
Pipes, 1½ to 2½ in.	4 17 6	to	5 2 6
,, 3 to 4 in.	4 10 0	to	5 0 0
,, 5 to 8 in.	4 7 6	to	4 10 0
,, 10 to 16 in.	4 7 6	to	4 10 0
,, 18 to 24 in.	4 7 6	to	4 10 0
Chairs	3 10 0	to	3 12 6
Floor plates (open sand)	3 0 0	to	3 2 6

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows:—Heavy wrought (mixed), £2 8s. 0d.; light wrought, £1 1s. 0d.; heavy cast, £2 7s. 0d.; all per ton f.o.b., London. Copper (clean), £55 0s. 0d.; brass (clean), £39 0s. 0d.; lead (usual draft), £11 15s. 0d.; tea lead, £10 5s. 0d.; zinc, £17 15s. 0d.; all per ton delivered merchant's yard.

Correspondence.

The Pickling of Castings.

To the Editor of the Foundry Trade Journal.

Sir,—Regarding the article on the above subject in last month's issue, I should like to ask whether the author is speaking from experience or theory when he states that it rests with the pickling operator whether a success or failure is made of the process, and that the exact strength of the mixture and period of immersion must be found out by experience. Cannot he state from practical experience what is the proper mixture and time? Yet in another place he says one part acid to ten parts water takes 10 or 12 hours. Is this statement from practical knowledge? I have been in machine tool works 14 years and pickled tons of castings, but have never allowed more than two hours for large and one hour for small castings. I have never used goggles, rubber apron or rubber gloves, clogs or vaseline. The only care required in using the acid is when putting it from the carboy into the pickling tank.

In conclusion, I should like to say that our more up-to-date foundries and pattern shops should be able to supply you with plenty of practical letters or articles that would rouse our sleepy foundries (and there are many) to a sense of appreciation of modern plant and more up-to-date methods.

Yours, etc., "F. H."

SILICA FIRE BRICK Co.,
OUGHTIBRIDGE.

GROUND GANISTER,
WET OR DRY.

Silco Cupola Bricks, 90% Silica.
Better than Fire-clay Bricks for Cupolas.

Established 1863.

JAS. DURRANS & SONS,

PHŒNIX WORKS, PENISTONE, Near Sheffield.

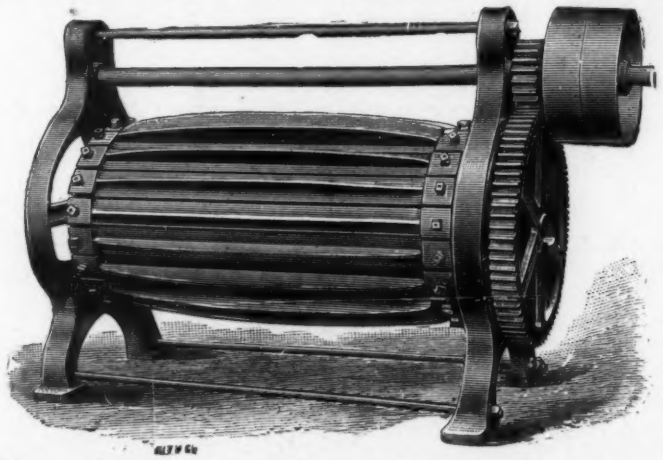
Manufacturers of all

FOUNDRY EQUIPMENTS,

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD."

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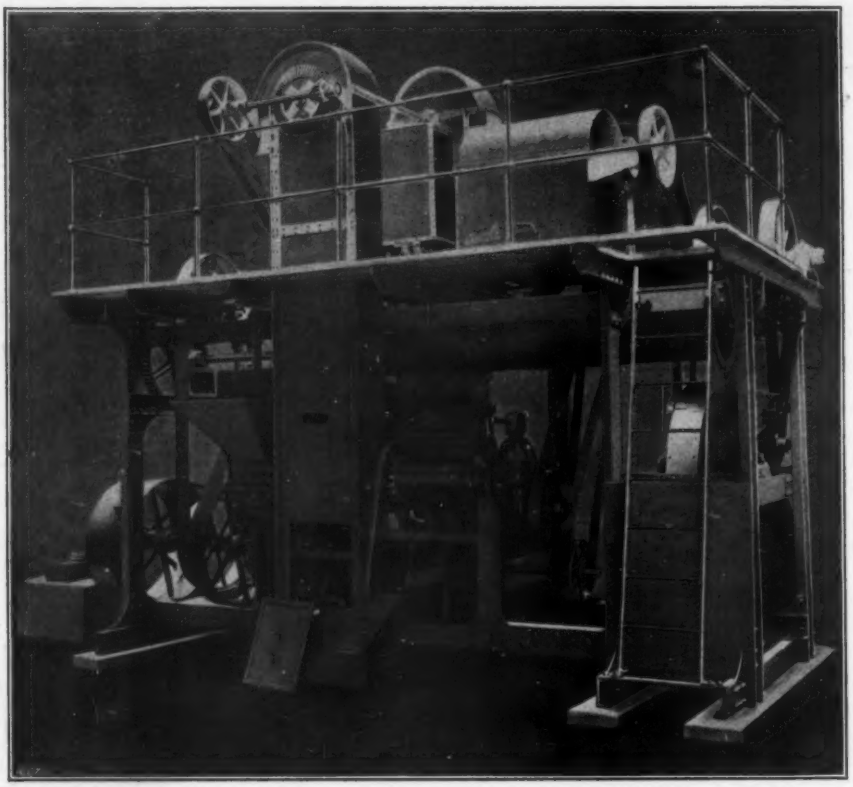

Advantages:—

Automatic Throughout.
Only One Operator Required.
Large Capacity.

Send for Pamphlet giving full particulars of this interesting Labour-Saving Apparatus.

TEN of these PLANTS have now been SUPPLIED.

Department A.—Emery Cloths, Glass and Flint Papers, etc.
" B.—Grinding Machines, Emery and Corundum Wheels, etc.
" C.—Foundry Plant, Sand Blasts, etc.

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Telegrams: "NAXIUM, LONDON." Telephone: TOTTENHAM 99.

THE BUYER'S GUIDE

Addresses and further information will be found by reference to the Firm's Advertisement.

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London Emery Works Co.
Jackman, J. W., & Co., Ltd.

Air Compressors.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Electrically Driven).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Steam).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Air Compressors (Belt).
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

Annealing.
Phillips, J. W & C. J.

Ash Crushing and Washing Machines.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Barrels (Tumbling).
Alldays & Onions Pneumatic Eng. Co., Ltd.
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Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Sonnenthal, Selig, & Co.
Tilghman's Patent Sand Blast Co., Ltd.

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Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.

Bellows.
Alldays & Onions Pneumatic Eng. Co., Ltd.
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Durrans, Jas., & Sons.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

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Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Walker, I. & I.
Wilkinson & Co., Thos., Ltd.

Blowers.
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Davies, T., & Son.
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Jackman, J. W., & Co., Ltd.
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Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Samuelson & Co., Ltd.
Sonnenthal, Selig, & Co.
Thwaites Bros., Ltd.
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Sonnenthal, Selig, & Co.

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Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Tilghman's Patent Sand Blast Co., Ltd.

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Jackman, J. W., & Co., Ltd.
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Olsen, Wm.
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Hall, Charles, & Co.
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Motherwell, Wm., & Co.
Olsen, Wm.
Wilkinson, T. & Co., Ltd.

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Jackman, J. W., & Co., Ltd.
Walker, I. & I.

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Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Thwaites Bros., Ltd.

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Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
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Elders Navigation Collieries.

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Marshall & Co., Horace P.
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Core Boxes.
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Jackman, J. W. & Co., Ltd.
Olsen, Wm.

Core Compounds.
Bush, H. C.
Cumming, Wm. & Co., Ltd.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W. & Co., Ltd.
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Wilkinson, Thos. & Co.

Core Gums.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
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Olsen, Wm.
Walker, I. & I.
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Core Making Machines.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
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London Emery Works Co
Marshall, H. P. & Co.
Phillips, J. W. & C. J.

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Hislop, R. & G.
Jackman, J. W. & Co., Ltd.
London Emery Works Co.
Phillips, C. D.
Phillips, J. W. & C. J.

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Bush, Henry C.
City of London Wood Wool Co.
Durrans, J. & Sons.
Evans, J., & Co.
Hall, Charles, & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.
Wilkinson, T. & Co.

Core Vents.
Bush, Henry C.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Olsen, Wm.

Cranes.
Alldays & Onions Pneumatic Eng. Co., Ltd.
Jackman, J. W., & Co., Ltd.
Ward, T. W., Ltd.

Crucibles.
Hall, Charles, & Co.
Olsen, Wm.

Crucible Furnaces.
Alldays & Onions Pneumatic Eng. Co., Ltd.
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Jackman, J. W., & Co., Ltd.
Simplex Coke Oven and Engineering Co., Ltd.

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Alldays & Onions Pneumatic Eng. Co., Ltd.
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Crushing Mills.
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Simplex Coke Oven and Engineering Co., Ltd.

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Alldays & Onions Pneumatic Eng. Co., Ltd.
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Durrans, J. & Sons.
Evans, J., & Co.
Jackman, J. W. & Co., Ltd.
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Marshall, H. P. & Co.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

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Foundry Blacking.
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Olsen, Wm.
Walker, I. & I.
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Durrans, J. & Sons.
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Alldays & Onions Pneumatic Eng. Co., Ltd.
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Hall, Charles, & Co.
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Phillips, J. W. & C. J.
Simplex Coke Oven Co. and Eng. Co., Ltd.

THE BUYER'S GUIDE.—*Continued.*

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Wilkinson & Co., Thos., Ltd.

Furnaces (Annealing).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Hislop, R. & G.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Brass).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Furnaces (Melting).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Davies, T., & Son.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

Ground Gannister.
Durrans, J., & Sons.
Dyson, J. & J.
Evans, J., & Co.
Lowood, J. Grayson, & Co.
Silica Firebrick Co.
Walker, I. & I.

Grinding Machines and Tools.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Sonnenthal, Selig, & Co.

Hammers (Steam).
Alldays & Onions Pneumatic Eng. Co., Ltd.
Thwaites Bros., Ltd.

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Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.

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Jackman, J. W., & Co., Ltd.
Marshall, H. P., & Co., Ltd.
Phillips, J. W. & C. J.
Thwaites Bros., Ltd.

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Davies, T., & Son.
Durrans, J., & Sons.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Ward, T. W., Ltd.

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Alldays & Onions Pneumatic Eng. Co., Ltd.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Microscopes.
Swift, James & Son.

Mould Driers.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.

Moulding Machines.
Bush, Henry C.
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
London Emery Works Co.
Marshall, H. P., & Co.
Phillips, J. W. & C. J.
Samuelson & Co., Ltd.
Simplex Coke Oven and Eng. Co., Ltd.
Whittaker, Wm., & Sons, Ltd.

Moulding Machines (Hand and Power).
Evans, J., & Co.
Jackman, J. W., & Co., Ltd.
Marshall & Co., Horace P.
Phillips, J. W. & C. J.
Simplex Coke Oven and Eng. Co., Ltd.

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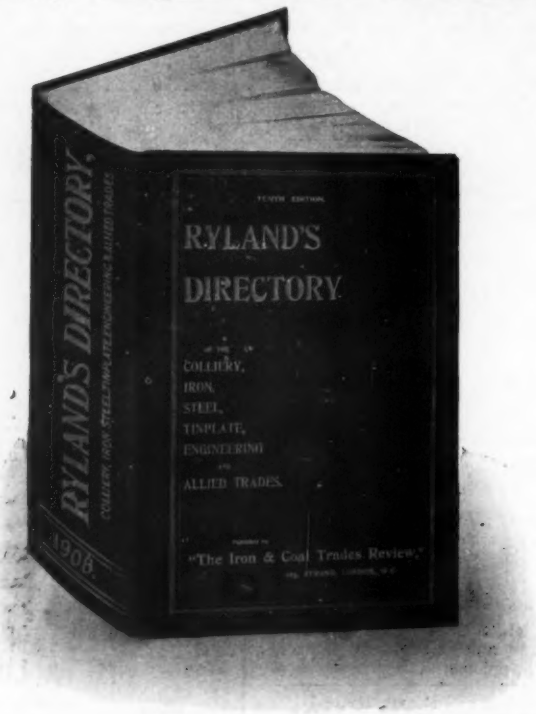

is out of print, sorry because we are bound to disappoint somebody, glad because of the increasing demand for this useful publication. We are in consequence of the above, making earlier arrangements and will produce RYLAND'S DIRECTORY, 1910, in January.

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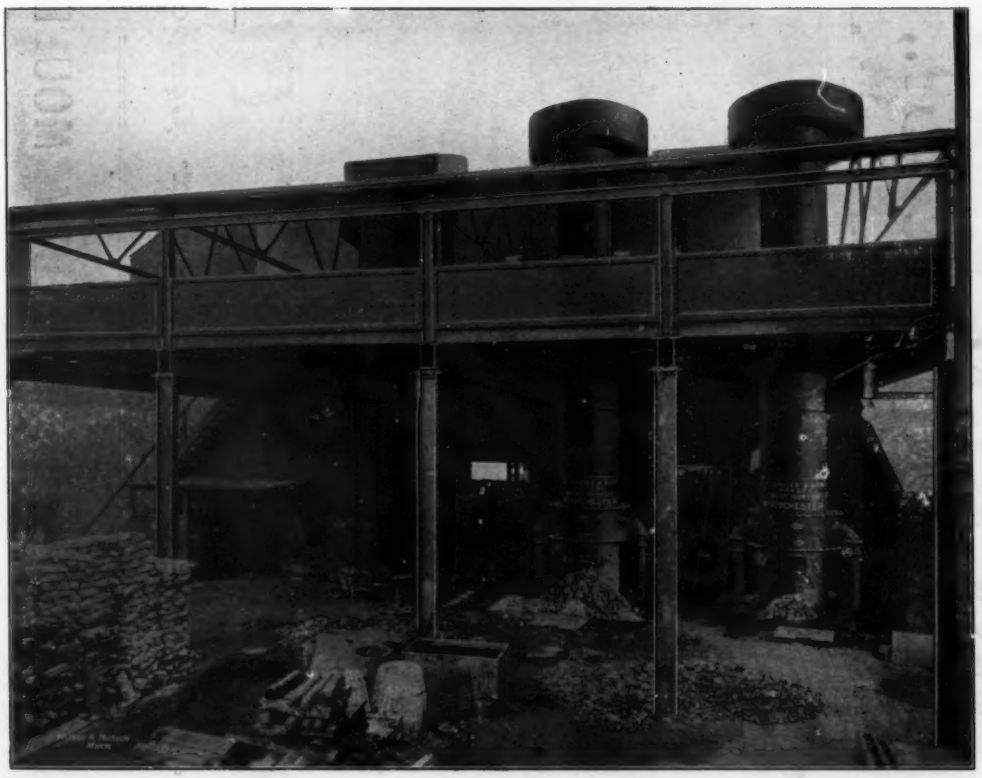

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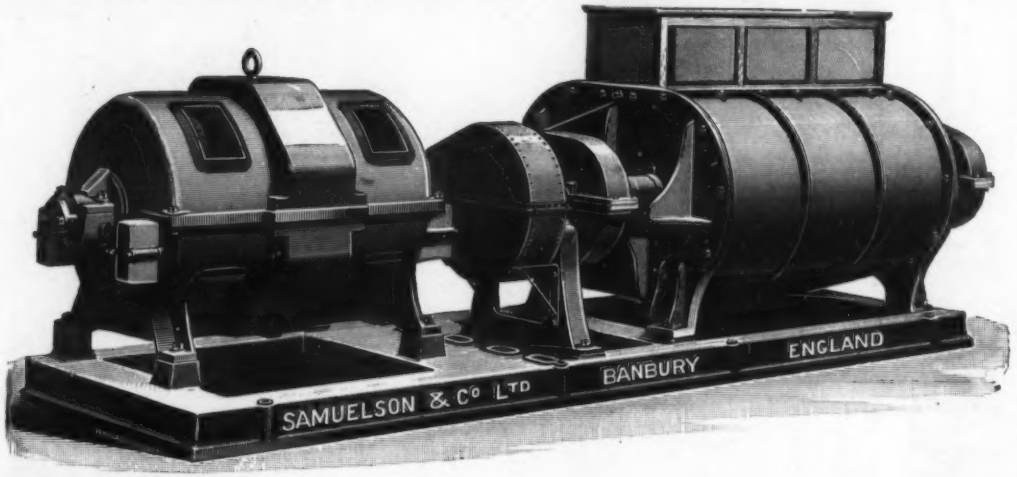

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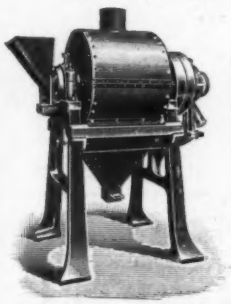

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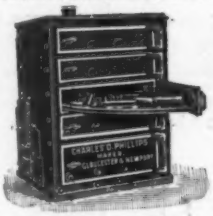

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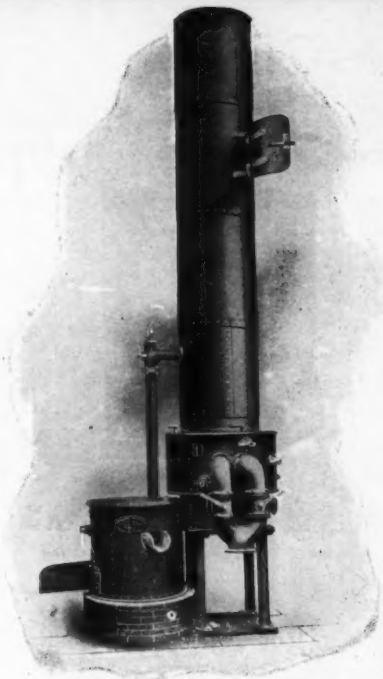

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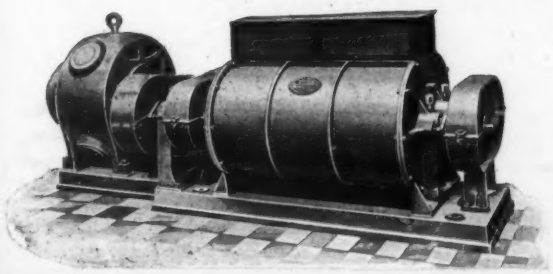

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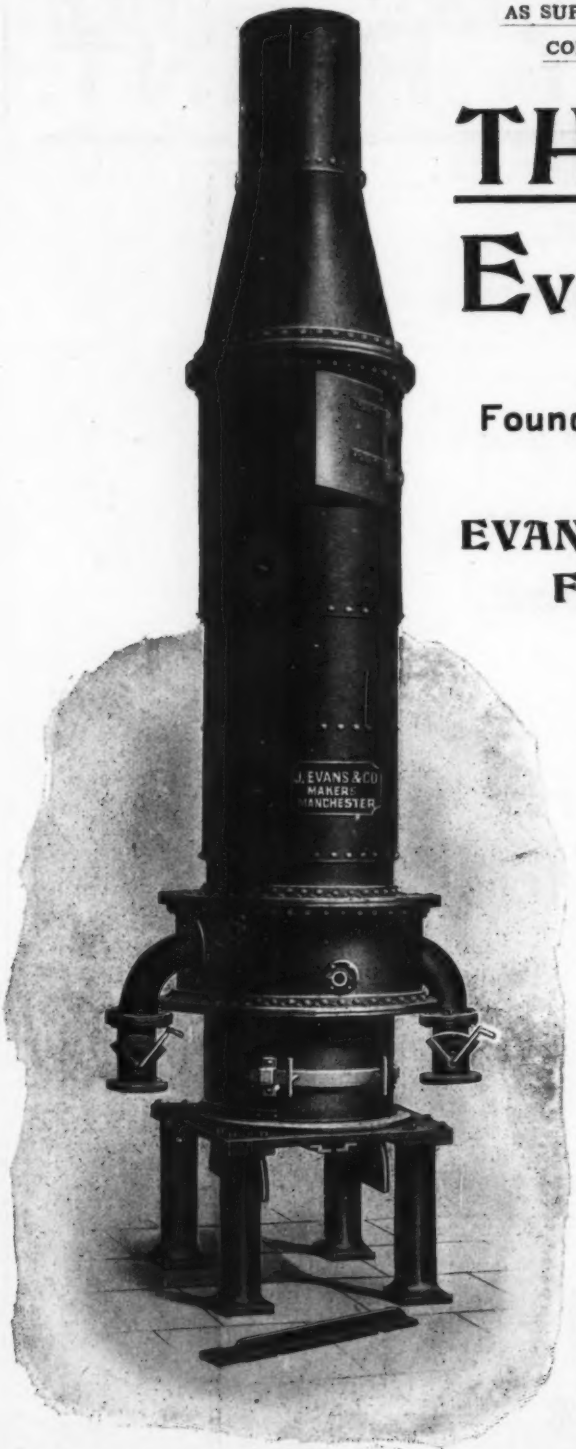

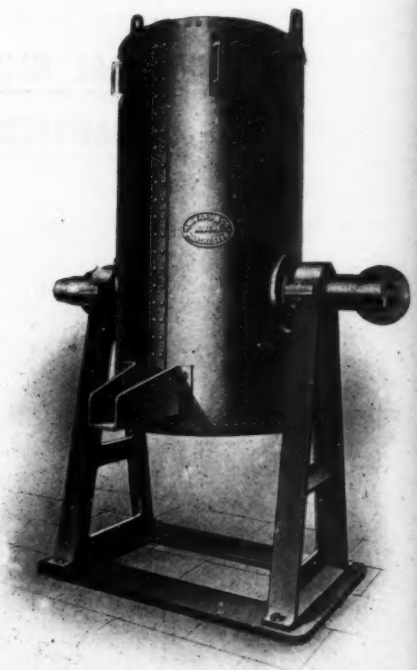

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